

# VEGETATION OF CHINA WITH REFERENCE TO ITS GEOGRAPHICAL DISTRIBUTION

HOU, HSIOH-YU (HOU XUE-YU)<sup>1</sup>

## THE PHYSICAL/GEOGRAPHICAL BACKGROUND OF CHINA'S VEGETATION

General references for this section include: Editorial Board of China's Vegetation (1980); Hou (1956, 1982).

China is situated in the eastern part of Asia, on the western coast of the Pacific Ocean. The distance from east to west measures over 5,000 km, and from north to south, over 5,500 km.

The topography of China is a three-step west-east staircase (Fig. 1). It begins with the Chinghai-Tibet Plateau, 4,000 m above sea level. Crossing Kunlun and Chilian ranges on the plateau's northern edge and the Hengtuan Mountains on its eastern edge, the land slopes away to highlands and basins mostly from 2,000 to 1,000 m above sea level; it then descends further eastward to hilly regions and plains below 1,000 m.

The summer monsoons greatly dominate the climate of the country. The southeast monsoon arising over the Pacific Ocean mainly influences the eastern half of China. The southwestern monsoon arising above the Bay of Bengal and the Indian Ocean mainly influences China's southern and southwestern regions. This is why coastal eastern China, especially the southeastern part, has comparatively heavy precipitation that is highly concentrated within a few summer months. The annual rainfall ranges from 600 to 1,000 mm in the northeast, and is mostly between 1,000 to 2,200 mm in the southeast. Atmospheric moisture decreases as one goes westward. Due to the long distance from the sea to the mountains and plateaus that obstruct the wet winds blowing in from the south and southeast, the northwestern parts of China have a low rainfall, mostly receiving an average of less than 100–500 mm annually. The land lying between the two regions mentioned above is semi-arid, having a mean annual rainfall of 300–400 mm. Thus, three vegetational regions, namely forests, steppes, and deserts, correspond to the humid, semi-arid, and arid climates (Fig. 2).

Because the northernmost point of China is at

about latitude 53°N, and the southernmost one at about latitude 4°N, the tremendous difference in latitude gives China wide variation in temperature. The eastern section can be divided into four climatic zones from north to south, namely, cold-temperate, temperate, subtropics, and tropics (Fig. 3). Accordingly, there occur four vegetational regions, namely, needle-leaved deciduous forests, broad-leaved deciduous forests, broad-leaved evergreen forests, and tropical semi-evergreen seasonal and rain forests.

Because both altitude and terrain also strongly influence the climate, climatic regions are very complicated in China (Fig. 4). The greater part of the Chinghai-Tibet plateau ranging from 4,000 to 5,000 m above sea level has a cold high-mountain climate with regions of subalpine forests, alpine meadows, alpine steppes, and alpine deserts.

There is a close relationship between the character of the soil and the nature of the underlying rock. However, climate, topography, and vegetation are just as important as rock in determining the ultimate nature of the soil. Because of the variation in soil formation factors mentioned above, the soil varies greatly from place to place in China (Fig. 5). In the same climatic zone, different vegetation types can occur on different soils.

In a country like China where numerous variations occur in physical features, climatic, and soil conditions, it is not surprising that many types of vegetation are to be found.

## CONCEPTS AND CLASSIFICATION OF VEGETATION

General references for this section include: Braun-Blanquet (1932); Chien et al. (1956); Kùchler (1964); Tansley (1953); UNESCO (1973); Walter (1973); Warming (1909); Weaver and Clements (1938); Whittaker (1962).

Different schools of geobotanists have developed various concepts concerning plant communities (the vegetation). I maintain that a plant

<sup>1</sup> Laboratory of Plant Ecology and Geobotany, Institute of Botany, Academia Sinica, 141 Hsi Chih Men Wai ta Chie, Beijing, People's Republic of China.



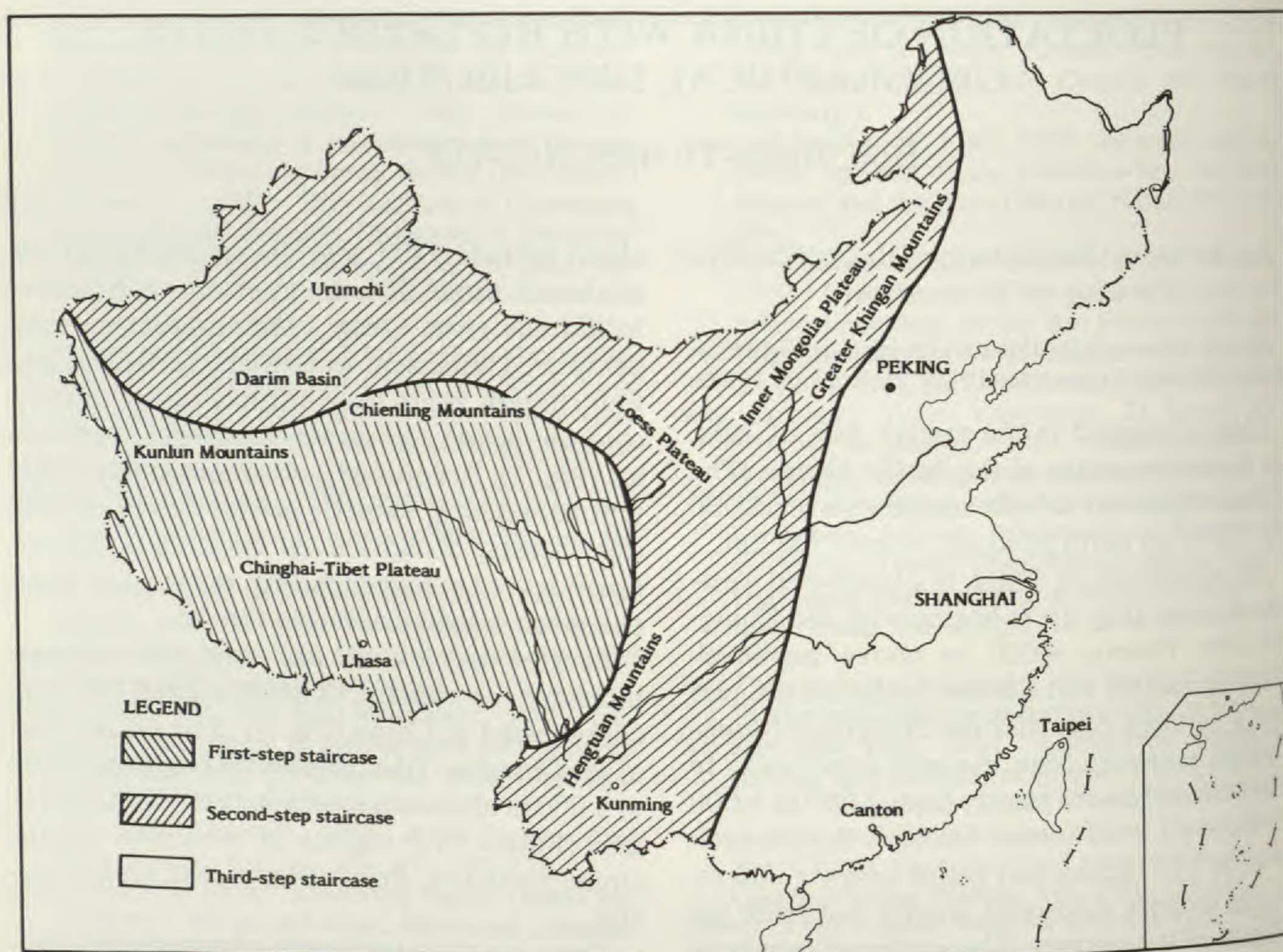


FIGURE 1. Map showing topography of China.

community, occupying a certain space, is an aggregate of plants occurring together in a common habitat. The groups of associated plants are to a certain extent similar in structure (including population, stratum, synusium), floristic composition, external appearance of the dominant species, and intimate functional interrelationships among each other, and in their relationship to environmental factors. From this viewpoint, a plant community can be considered to be a system that includes not only the plants of which it is composed, but also the natural geographic environment of habitat that forms a recognizable self-containing entity. It also means that either the climax or serial stages, and either natural or man-made ones are all considered to be part of the plant community (Hou, 1960, 1979, 1982).

Based on the plant community concept just given, the following four criteria should be thoroughly considered when classifying vegetation: (a) life or growth forms of dominant plants; (b) strata and synusia; (c) dominant floristic composition with the help of character (indicator or diagnostic) species; (d) habitat or environment.

Only two of the higher vegetational categories

in China are used in this paper. The highest one can be called "vegetation type," which corresponds approximately to "formation class" suggested by UNESCO (1973). This unit refers to the plant community in which the dominant plants in the dominant layer have a common life or growth form, including needle-leaved forests, broad-leaved forests, shrubs and coppicelands, deserts and xerophytic shrubs, steppes and savannas, meadows, and swampy herbaceous vegetation.

The vegetation category mainly described in this paper can be called "formation class," which is to a great extent similar to the term "formation group" (UNESCO, 1973). This category refers to communities that have a certain common floristic composition, including families and genera, in addition to the same life or growth forms of their dominants. The geographical distribution of this category corresponds essentially to a certain latitudinal, longitudinal, or vertical zonation. Thus, supplementary terms referring to climate, soil, and landforms are added to the names to help in the identification of a given category.



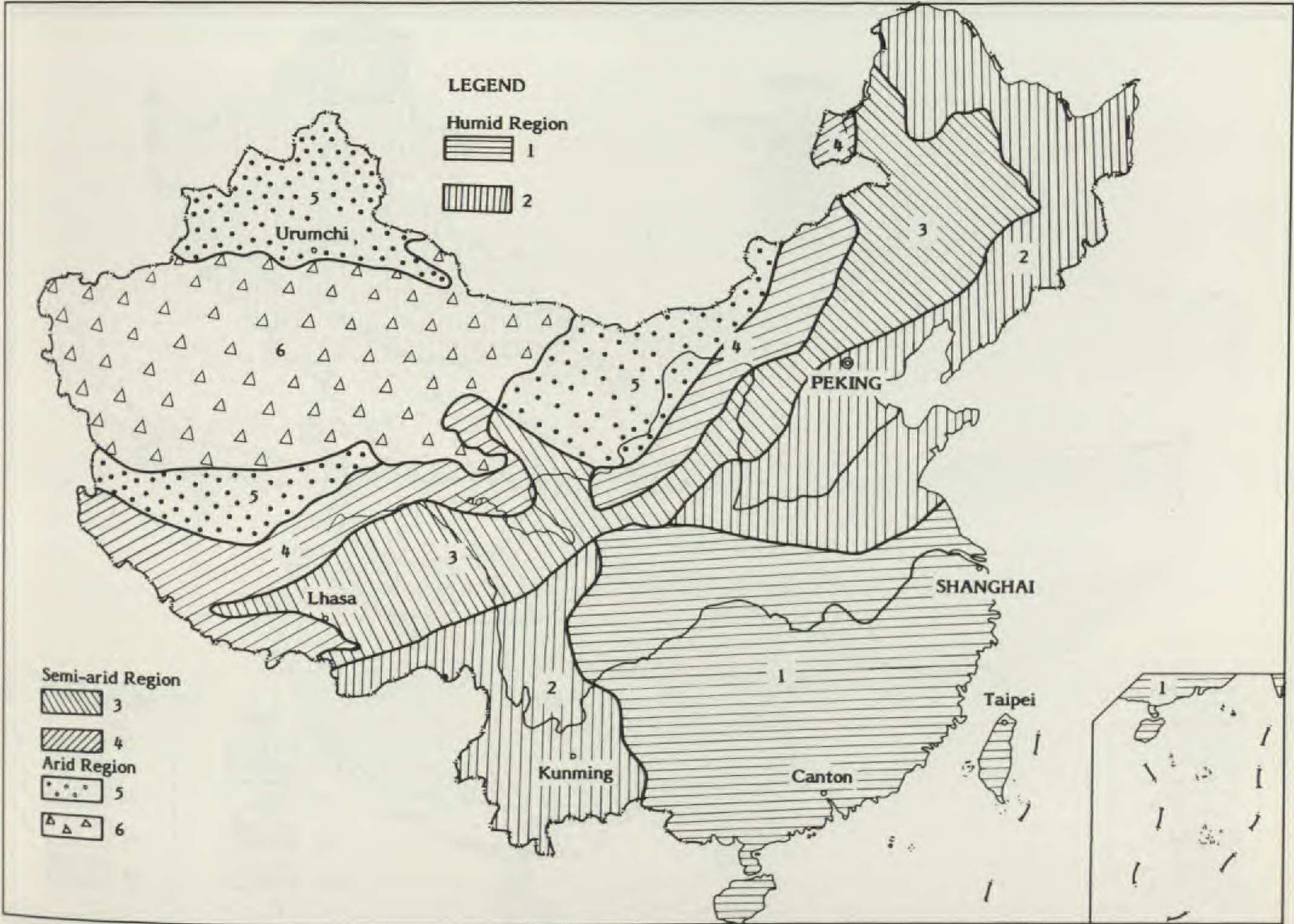


FIGURE 2. Map showing regions of atmospheric moisture of China: 1) Humid region with non-distinct dry season; 2) Humid region with distinct dry season; 3) Semi-humid region; 4) Semi-arid region; 5) Arid region; 6) Extremely arid region.

VEGETATION TYPES OF CHINA AND THEIR  
GEOGRAPHICAL DISTRIBUTION

NEEDLE-LEAVED FORESTS

1. *Needle-leaved deciduous forests (light taiga) of the cold-temperate zone or on the mountains of the temperate zone.* Reference: Chang (1955). Larch forests, being light-demanding, can endure a greater degree of dryness than spruce and fir forests. They can be found on either dry, sunny slopes or in moist valleys and lowlands. *Larix gmelini* forests occur chiefly on the Greater Khingan Mountains in extreme northern China, where the climate is continental boreal. These forests have an undergrowth of dwarf shrubs, the drier with *Vaccinium vitis-idaea* and the wetter with *Ledum palustre*. In the Altai, in northwesternmost China, the predominant tree is replaced by *Larix sibirica*, often growing with *Pinus sibirica*. *Rhododendron dauricum* appears frequently in the shrub layer of this forest (Fig. 6).
2. *Needle-leaved evergreen forests (dark taiga)*

*on mountains of the temperate zone.* References: Chen et al. (1964); Chow and Li (1964); Integrated Survey Team of Sinkiang and Institute of Botany, Academia Sinica (1978); Teng (1947). The shady coniferous forests dominated by *Picea obovata*, *Abies sibirica*, and *Pinus sibirica* are confined to the northwesternmost corner of the Altai Mountains, whereas those of *Picea jezoensis*, *P. koraiensis*, *Abies nephrolepis*, *A. holophylla*, and *Pinus sylvestris* var. *mongolica* are extensively distributed in the northeastern mountains of China. The climate of the two above-mentioned regions is much more humid than that of places where only spruce forests occur. On the mountains of Tianshan, Chilianshan, and Honan, which are situated in the central part of the arid desert region, only spruce forests, dominated by *Picea shrenkiana* and *P. crassifolia*, but no fir forests, are found (Figs. 7, 8).

3. *Needle-leaved evergreen woodlands on semi-arid sandy soil of the temperate zone.* Reference: Zhao (1958). The precipitation of the semi-arid steppe, which ranges from 300 to 400 mm yearly,



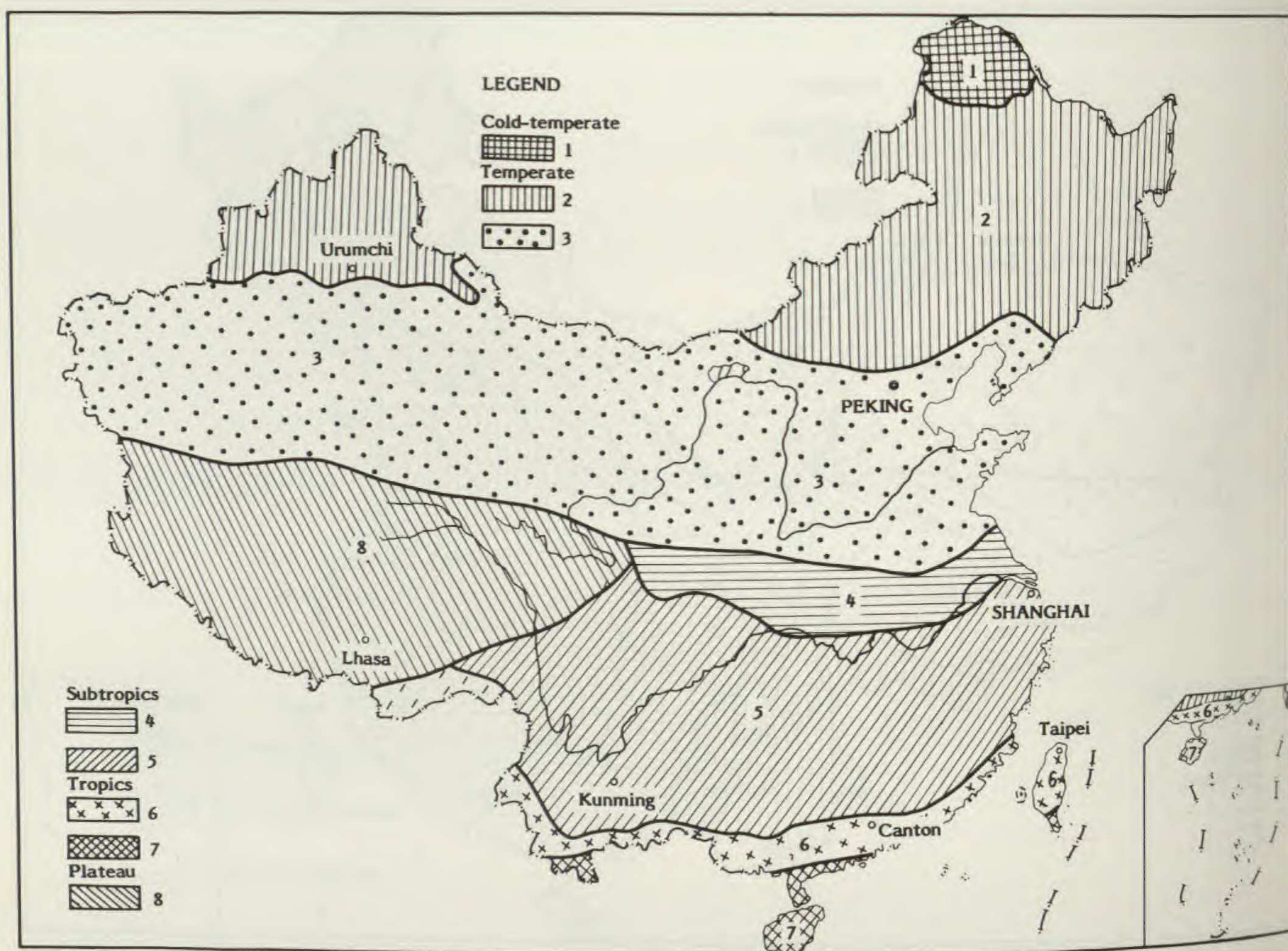


FIGURE 3. Map showing regions of atmospheric warmth of China: 1) Cold-temperate; 2) Temperate; 3) Warm-temperate; 4) Transitional subtropics; 5) Subtropics; 6) Transitional tropics; 7) Tropics; 8) Cold high-mountain climate.

is much less than in humid areas. However, the sandy soil can retain larger amounts of rainwater than the loamy soil on which grasses grow. More or less open and scattered woodlands dominated by *Pinus sylvestris* var. *mongolica* grow on the sandy soils. This type of woodland has an undergrowth of steppe species and not forest species (Fig. 9).

4. *Needle-leaved evergreen forests of the temperate zone.* These forests are distributed on the hills and mountains of the North China Plain that are under the influence of the summer monsoon. One type of forest, consisting of *Pinus tabulaeformis* inland and *P. densiflora* along the coast, occurs on acid brown soils. Another group, dominated by *Platycladus orientalis*, is seen on neutral or calcareous Korichnevie soils. This type of forest is usually associated with deciduous broad-leaved trees and shrubs (Chen et al., 1954, 1965; Chow, 1963) (Fig. 10).

5. *Needle-leaved evergreen forests of subtropical and tropical zones.* References: Chow

(1957); Ho and Chen (1963); Kiang (1958); Wu (1955). These forests are composed of warm-loving needle-leaved trees belonging to Pinaceae, Taxodiaceae, and Cupressaceae, and are usually accompanied by some evergreen broad-leaved trees and shrubs. Forests growing on acid soils include *Pinus massoniana*, *P. yunnanensis*, *P. armandii*, and *Cunninghamia lanceolata* in the subtropics, and *Pinus khasya* and *P. finlaysonianana* in the tropics. The montane *Pinus taiwanensis* forests and mixed *Cathaya argyrophylla* forests are also found on acid soils in the subtropics. Another group, including *Cupressus funebris* and *C. duclouxiana*, thrives on limestone soils (Figs. 11, 12, 13).

6. *Needle-leaved evergreen forests on mountains (subalpine conifers) of subtropical and tropical zones.* References: Chiang (1963); Editorial Board of Szechuan's Vegetation (1980); Teng (1948). Because air temperature decreases with increasing altitude, on mountain ranges between 2,500 to 4,000 m above sea level in subtropical



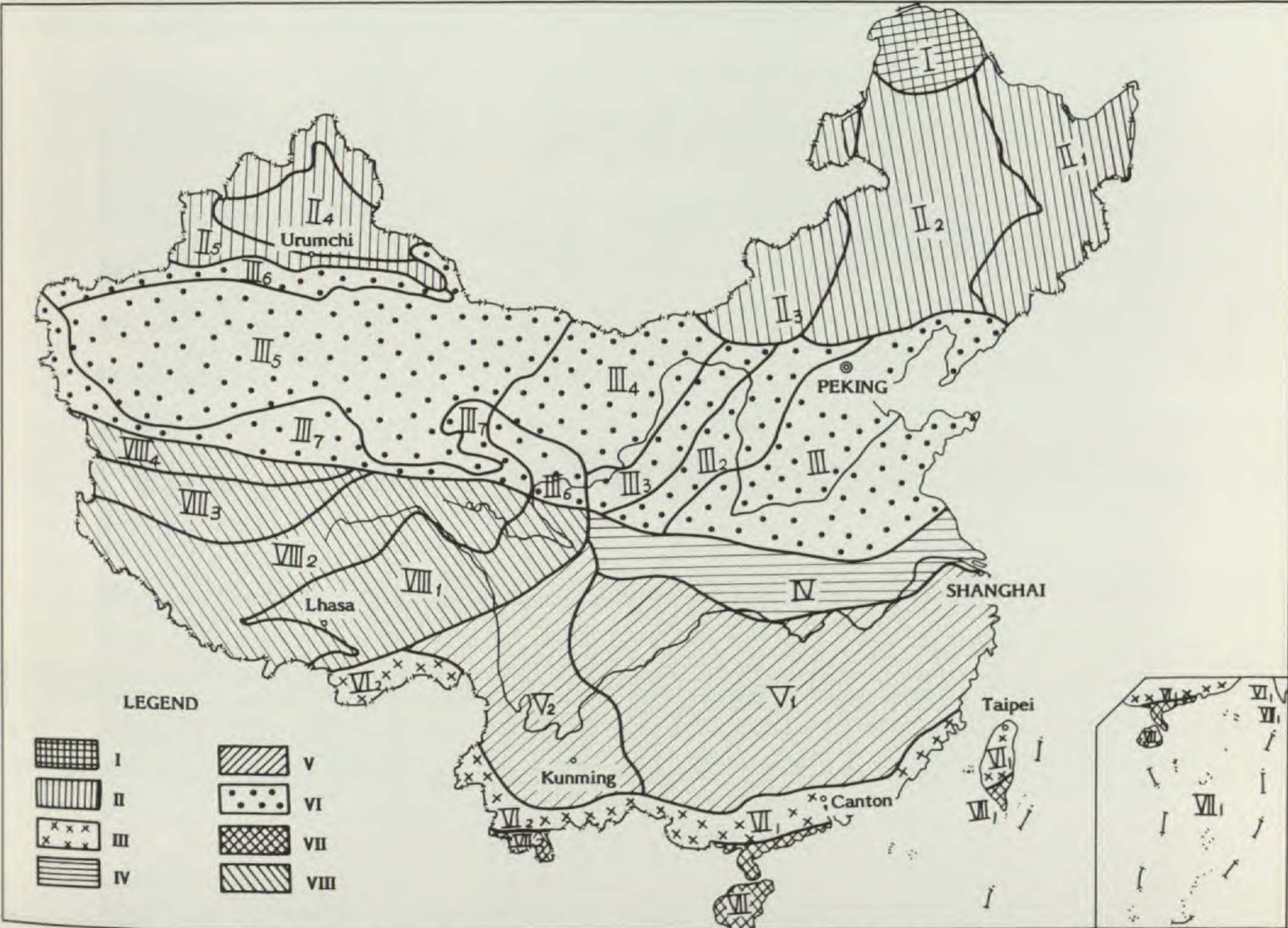


FIGURE 4. Map showing climatic regions of China: I) COLD-TEMPERATE ZONE—Humid region; II) TEMPERATE ZONE—II1. Humid region with distinct dry season, II2. Semi-humid region, II3. Semi-arid region, II4. Arid region with evenly-distributed rainfall, II5. Semi-arid and humid montane region; III) WARM-TEMPERATE ZONE—III1. Humid region with distinct dry season, III2. Semi-humid region, III3. Semi-arid region, III4. Arid region, III5. Extremely arid region, III6. Montane semi-arid region, III7. Montane extremely arid region; IV) TRANSITIONAL SUBTROPICS—Humid region with non-distinct dry season; V) SUB-TROPICS—V1. Humid region with non-distinct dry season, V2. Humid region with distinct dry season; VI) TRANSITIONAL TROPICS—VI1. Humid region with non-distinct dry season, VI2. Humid region with distinct dry season; VII) TROPICS—VII1. Humid region with non-distinct dry season; VII2. Humid region with distinct dry season; VIII) COLD HIGH-MOUNTAIN REGION IN SUB-TROPICAL ZONE—VIII1. Semi-humid region, VIII2. Semi-arid region, VIII3. Arid region, VIII4. Extremely arid region.

and tropical zones, climatic conditions are found that, in some ways, resemble those of the cold-temperate zone. Because of this, evergreen coniferous forests consisting of fir, spruce, and pine can survive on the mountains at low latitudes. Although there are obvious similarities between the mountain climate of the subtropics and tropics and that of the cold-temperate zone, there are also many differences. On southern mountains the day temperatures in spring and autumn are higher and the light and heat intensity at midday are much greater throughout the year. In addition, the precipitation and humidity are much higher than those of the temperate zone. It is small wonder that the southern subalpine conifers have the following characteristics:

(a) There are many species of fir and spruce, namely, *Abies faxoniana*, *A. georgei*, *A. forrestii*, *A. faberi*, *A. fargesii*, *A. cheniensis*, *A. squamata*, *A. delavayi*, *A. spectabilis*, *A. kawakamii*, *Picea asperata*, *P. purpurea*, *P. likiangensis*, *P. brachytyla*, *P. morisonicola*, *P. spinulosa*; (b) The tree layer is associated with evergreen, broad-leaved *Quercus* and *Rhododendron* species, as well as *Tsuga chinensis* and *T. dumosa*, which are not found in the northern evergreen conifer forests; (c) In the shrubby layer there are no arctic plants, such as *Vaccinium vitis-idaea* and *Ledum palustre*, but rather higher evergreen shrubs such as *Rhododendron* and *Quercus* species, as well as bamboo



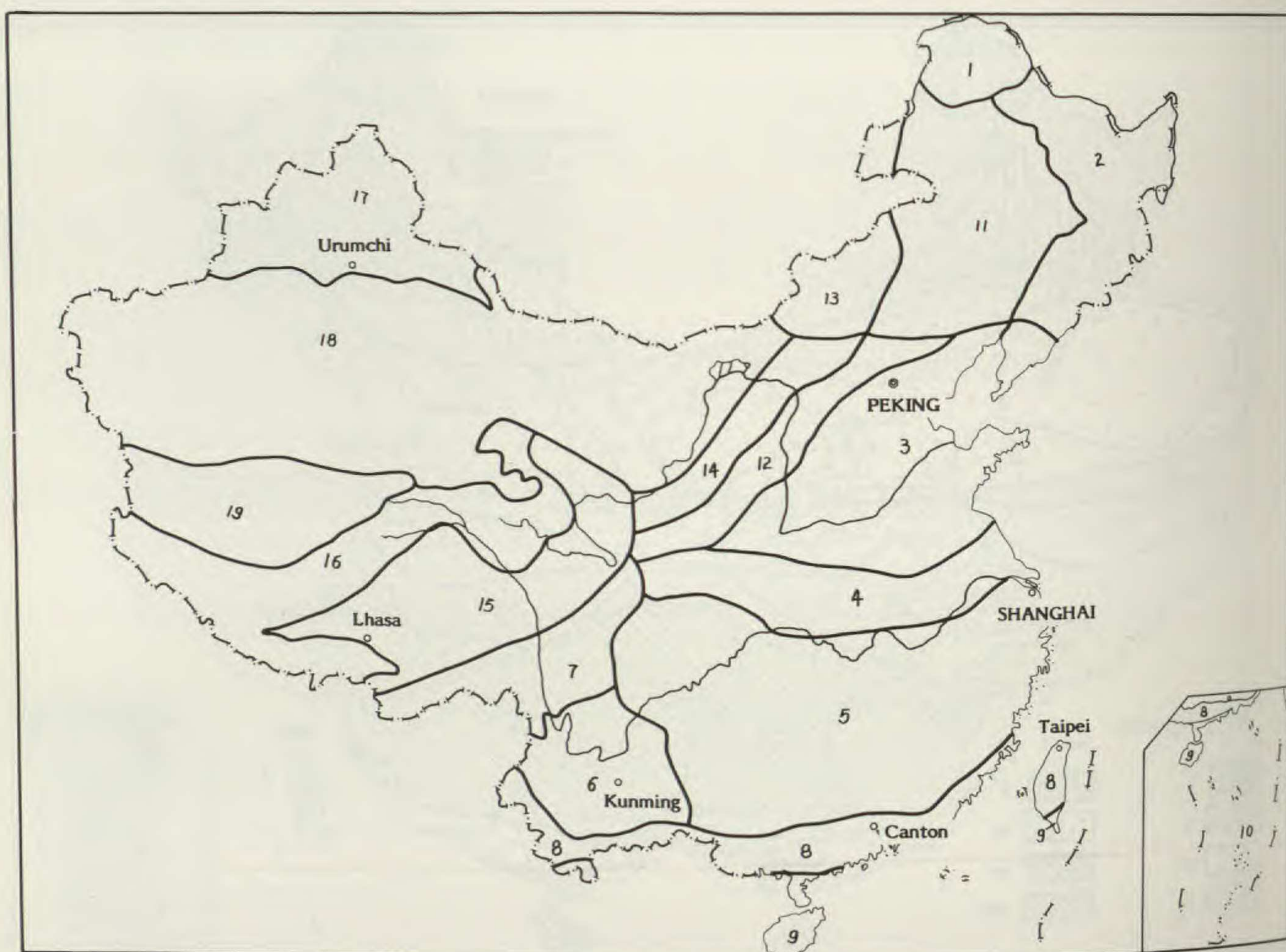


FIGURE 5. Map showing soil regions of China. **FOREST SOIL REGIONS:** 1) Brown conifer soil region; 2) Dark brown soil region; 3) Brown soil, Korichnevie soil, alluvial soil region; 4) Yellow-brown soil, Yellow-Korichnevie soil region; 5) Yellow and Red Earth, Purple soil, Rendzina soil region; 6) Red earth region; 7) Subalpine conifer soil region; 8) Lateritic soil region; 9) Laterite region; 10) Phosphorus lime soil region. **GRASSLAND SOIL REGIONS:** 11) Chernozem soil region; 12) Ziero-Korichnevie soil region; 13) Chestnut soil region; 14) Zierozem soil region; 15) Cold high-mountain meadow soil region; 16) Cold high-mountain steppe soil region. **DESERT SOIL REGIONS:** 17) Gray-brown desert soil region; 18) Brown desert soil region; 19) Cold high-mountain desert soil region.

shrubs such as *Sinarundinaria* and *Pleioblastus* (Fig. 14).

#### BROAD-LEAVED FORESTS AND WOODLANDS

1. *Mixed broad-leaved deciduous and needle-leaved evergreen forests of the temperate zone.* References: Chen et al. (1964); Chow and Li (1964); Liu (1955). The mixed forests belong to the transitional type of vegetation between evergreen conifer and deciduous broad-leaved forests. They grow on acid dark-brown soils on the northeastern mountains of China. The forests are characteristically rich in floristic composition and contain some relicts. The deciduous broad-leaved trees mainly belong to the Ulmaceae, Aceraceae, Leguminosae, Tiliaceae, Juglandaceae, Oleaceae, Salicaceae, Araliaceae, etc. The following trees can be noted as representative: *Ulmus*

*propinqua*, *Maackia amurensis*, *Fraxinus mandschurica*, *Tilia amurensis*, *T. mandschurica*, *Acer mono*, *Juglans mandschurica*, *Populus davidiana*, *P. koreana*, *Betula platyphylla*, *Quercus mongolica*, *Carpinus cordata*, *Phellodendron amurense*. The evergreen conifers are usually dominated by *Pinus koraiensis*, frequently by *Abies holophylla*, and rarely by *Taxus cuspidata* (Fig. 15).

2. *Broad-leaved deciduous forests of the temperate and subtropical zones.* References: Chen (1958); Chen et al. (1965); Numata (1974). The broad-leaved deciduous forests (known as summer-green forests) in China are mainly composed of trees belonging to the Fagaceae, Aceraceae, Tiliaceae, Oleaceae, Ulmaceae, Leguminosae, Juglandaceae, and Betulaceae. Because of the influence of a continental climate in North China, these forests differ from those in Japan and the





FIGURE 6. *Larix gmelini* forest growing on acid podzolic soil in the Greater Khingan Mountains is the typical vegetation of cold-temperate regions.

eastern United States in the absence of beeches (*Fagus* spp.). These humid-loving trees are confined to the humid subtropics in China. This type of vegetation can be classified into two groups, namely deciduous oak forests and mixed hardwood forests. The oak forests are found in relatively open and light habitats. The sequence of

horizontal distribution of the dominant oaks in the temperate zone from north to south is as follows: *Quercus mongolica*, *Q. liaotungensis*, *Q. aliena*, *Q. dentata*, *Q. aliena* var. *acuteserrata*, *Q. variabilis*, *Q. acutissima*, *Q. glandulifera*. The second group of forests has no dominant species, but is composed of mixed hardwoods. The mixed





FIGURE 7. (Upper) At altitudes between 1,100 and 1,800 m on the Changpai Mountains, needle-leaved evergreen forest dominated by *Abies nephrolepis* and *Picea jezoensis* associated with its secondary growth, *Betula platyphylla*, is found on the lower slopes.

FIGURE 8. (Lower) At about 3,000 m altitude in northern Tianshan of the desert region, *Picea shrenkiana* forest is found on shady slopes and mountain steppe on sunny slopes.





FIGURE 9. (Upper) In the semi-arid region sandy soil can retain larger amounts of rainwater than the loamy soil on which grasses grow, so that on the sandy soil grows scattered woodland which is dominated by *Pinus sylvestris* var. *mongolica* with an undergrowth and ground cover of steppe vegetation.

FIGURE 10. (Lower) In the warm-temperate region, deciduous oak forest without beech growing on slightly acid soil is typical. However, *Pinus tabulaeformis* forest with an undergrowth of *Cotinus coggygia* var. *cinerea* also occurs here.





FIGURE 11. (Upper) After cutting of the broad-leaved evergreen forest in the subtropical region, *Cunninghamia lanceolata* forest (upper slope) and *Phyllostachys pubescens* (lower slope) take over.

FIGURE 12. (Lower) *Pinus massoniana* forest with *Rhododendron simsii* as an undergrowth is a secondary growth of the broad-leaved evergreen forest.





FIGURE 13. (Upper) *Cupressus funebris*, a calcium-loving tree, is the secondary growth of the mixed deciduous and evergreen broad-leaved forest on limestone soil.

FIGURE 14. (Lower) *Picea fabri* forest mixed with *Tsuga chinensis* is seen on the western mountains in the Szechuan Basin from 2,000 to 3,000 m elevation.



forests, growing on acid soils in shady and moist slopes or valleys, consist of *Acer* and *Tilia* species, *Fraxinus mandshurica*, *Ulmus propinqua*, *Betula platyphylla*, etc., whereas those growing on calcareous or limestone soils are composed of *Ulmus pumila*, *U. parvifolia*, *Celtis sinensis*, *C. bungeana*, *C. julianae*, *Zelkova schneideriana*, *Pteroceltis tatarinowii*, *Pistacia chinensis*, *Sophora japonica*, *Broussonetia papyrifera*, *Tilia mongolica*, *Dalbergia hupeana*, and *Ailanthus altissima* (Fig. 16).

3. *Montane microphyllous deciduous forests of temperate and subtropical zones.* Dominant trees of these forests include species of *Betula* and *Populus*. They are usually secondary, replacing cold-temperate or subalpine conifers after felling or fires. *Betula platyphylla* forests are distributed in the cold temperate zone and on mountains of the temperate zone, whereas the forests dominated by *Betula albo-sinensis* and *B. platyphylla* var. *szechuanica* frequently occur on the mountains in the subtropics. However, *Betula ermanii* often forms pure, virgin stands located at the upper limit of montane evergreen conifer forests in the temperate zone, and its lower limit can reach 1,000 to 1,800 m in the northeastern mountains of China. *Populus davidiana* can accompany *Betula platyphylla*; however, it can also be found in areas where the climate is warmer (Fig. 17).

4. *Microphyllous deciduous woodlands of the temperate zone.* References: Chen and Chow (1957); Ching (1959). There are two groups of this type of woodland. One type is distributed along the rivers of the arid region and is dominated by *Populus euphratica* (*P. diversifolia*). This species is widespread on the flood plain of the Darim River, which is fed by water from the glaciers and snows of the high surrounding mountains. It also is frequently encountered in a limited area on river banks in all desert regions. The soil in which *P. euphratica* grows is slightly saline with a water table of about 1 to 3 m. Another species is *Populus pruinosa*, found on soils with a lower salt content. *Elaeagnus angustifolia* woodland also is found on saline soil. *Ulmus pumila* woodland, which occurs more frequently on sandy soil in the semiarid steppe region, sometimes also is found in desert regions that have a water supply (Fig. 18).

5. *Mixed broad-leaved deciduous and evergreen forests on limestone soils of the subtropical zone.* References: Chow (1957); Chu and Wen (1953); Wang (1956). Because limestone has ex-

cessive drainage through sinkholes, and because rock surface temperature fluctuates greatly between day and night in the subtropics, the local soil climate is comparatively dry. For this reason, the mixed forests consist of a mixture of calcium-loving, xerophilous, deciduous trees. Most belong to the Ulmaceae, Cornaceae, Juglandaceae, Moraceae, Leguminosae, Sapindaceae, Anacardiaceae, Rhamnaceae, etc. The most common evergreen broad-leaved trees are *Cyclobalanopsis* (Fagaceae), *Cinnamomum* (Lauraceae), *Osmanthus* (Oleaceae), *Eriobotrya*, and *Photinia* (Rosaceae) (Fig. 19).

6. *Mixed broad-leaved deciduous and evergreen montane forests on acid yellow-brown soils of the subtropical zone.* References: Editorial Board of Szechuan's Vegetation, 1980; Jian et al., 1975; Kiang, 1958; Wang, 1964. This type of mixed montane forest is widely distributed on mountain slopes at 1,000 to 1,900 m level in the humid subtropics. Because of lower temperatures on mountains, the warm-loving evergreen species of broad-leaved evergreen forests are replaced by the cold-resistant ones, mixed with deciduous broad-leaved trees. The trees of the mixed forests belong mainly to the Fagaceae, Aceraceae, Betulaceae, Hamamelidaceae, Styracaceae, Araliaceae, Magnoliaceae, Lauraceae, Theaceae, Ericaceae, Symplocaceae, Anacardiaceae, Rosaceae, Oleaceae, and Tiliaceae. These forests are characterized by the presence of the humid-loving trees, including *Fagus engleriana*, *F. longipetiolata*, and *F. lucida*, species that are not seen in the temperate zone of China. It should be noted that these forests embrace many characteristic species such as *Cercidiphyllum japonicum* var. *sinense*, *Tetracentron sinense*, *Bretschneidera sinensis*, *Davidia involucrata*, *Camptotheca acuminata*, *Nyssa sinensis*, *Aesculus chinensis*, *A. wilsonii*, *Liriodendron chinense*, and *Emmenopterys henryi* (Fig. 20).

7. *Broad-leaved evergreen forests of the subtropical zone.* References: Editorial Board of Szechuan's Vegetation (1980); Jian et al. (1975); Lin et al. (1965); Liu (1939); Shan and Liu (1963). Broad-leaved evergreen forests represent zonal vegetation found in areas with distinct dry seasons on mountains below 1,100 m in the eastern humid subtropics and on mountains between 1,500 and 3,000 m in the western subtropics of the Yunnan Highland. These forests can be classified as belonging mainly to two groups. One group contains evergreen oak forests, composed mainly of *Cyclobalanopsis*, *Castanopsis*, and





FIGURE 15. (Upper) Mixed broad-leaved deciduous and needle-leaved evergreen forest is found on the Changpai Mountains, between 500 and 1,100 m elevation. *Pinus koraiensis* is the typical conifer, whereas the broad-leaved trees include *Ulmus*, *Acer*, *Tilia*, *Fraxinus*, *Phellodendron*, *Carpinus*, and *Juglans*.

FIGURE 16. (Lower) At the foot of the Changpai Mountains at 200 to 500 m elevation *Quercus mongolica* forest is seen on sunny slopes.





FIGURE 17. (Upper) *Betula ermanii* occurs at the upper limit of forest lying between 1,800 and 2,000 m elevation in the Changpai Mountains of the temperate region.

FIGURE 18. (Lower) Gallery woodland dominated by *Populus diversifolia* is frequently distributed on meadow soil with ground water at a depth of several meters.



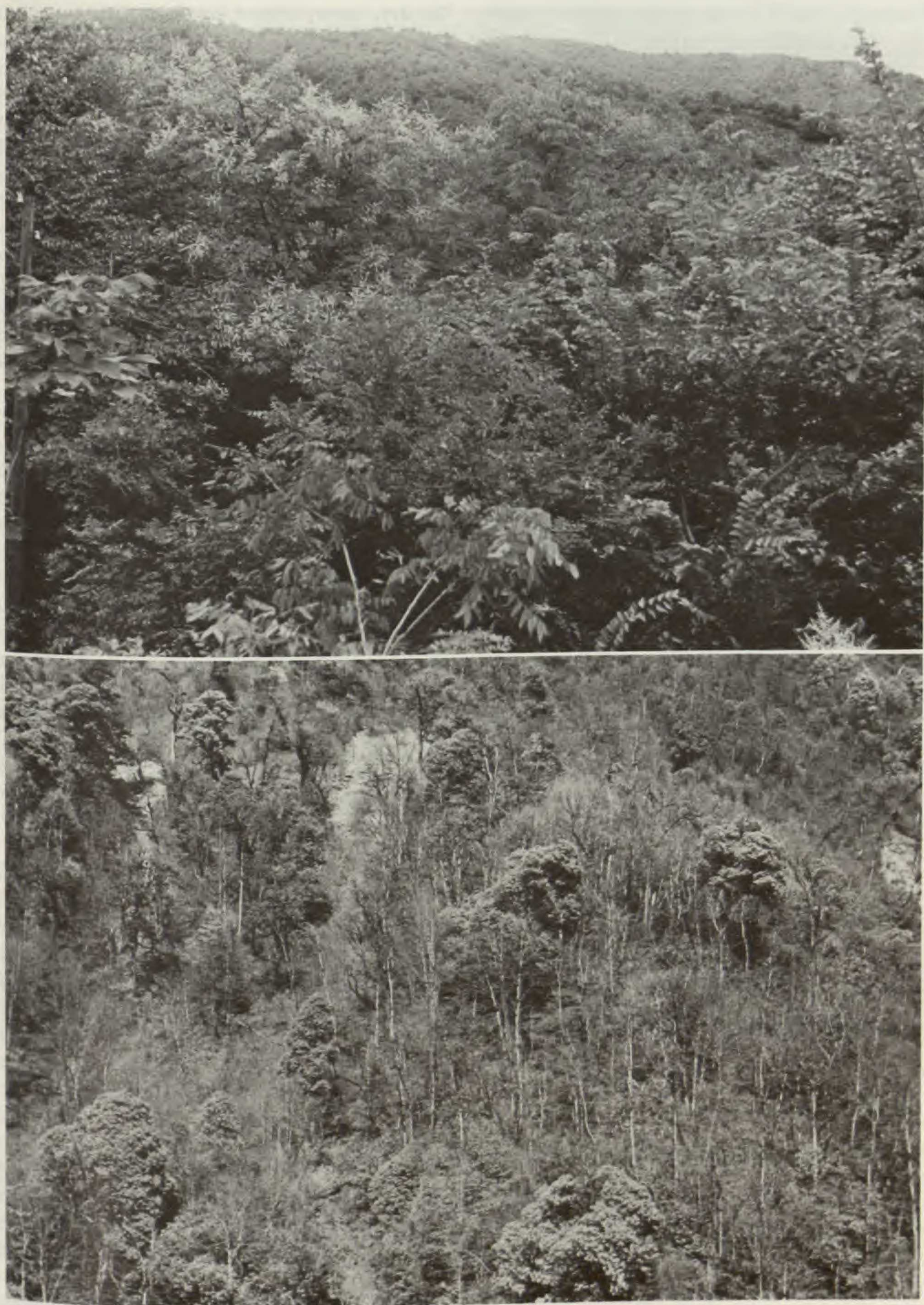


FIGURE 19. (Upper) In the subtropical region on limestone hills, mixed broad-leaved deciduous and evergreen forest is frequently found. The calcium-loving deciduous trees belong mostly to the Ulmaceae, Anacardiaceae, Sapindaceae, and Moraceae. The most common evergreen broad-leaved trees are *Cyclobalanopsis* (Fagaceae), *Cinnamomum* (Lauraceae), *Osmanthus* (Oleaceae), and *Eriobotrya* (Rosaceae).

FIGURE 20. (Lower) Mixed broad-leaved deciduous and evergreen forest mixed with beech is found at about 1,800 m elevation in the mountains of the western Szechuan Basin.



*Lithocarpus*, which occur in the northern subtropics. The dominant members of this group in the eastern region include *Cyclobalanopsis glauca*, *Castanopsis eyrei*, *C. sclerophylla*, and *Lithocarpus glaber*, and are often intermingled with *Fagus lucida* and *F. longipetiolata*. In the western subtropical region, the dominant species of evergreen oaks include *Cyclobalanopsis glaucoides*, *C. delavayi*, *Castanopsis delavayi*, *C. orthacantha*, *Lithocarpus dealbatus*, but without species of *Fagus*. The second group consists of mixed evergreen broad-leaved forests, dominated by warm-loving species of *Castanopsis*, as well as those of Lauraceae and Theaceae. In the eastern region, the dominant trees are *Castanopsis hystrix*, *C. carlesii*, *C. faberi*, *C. armata*, *C. chinensis*, *C. concinna*, *C. fissa*, *Schima superba*, *Adinandra bockiana*, *Polyspora axillaris* (*Gordonia axillaris*), *Ternstroemia gymnanthera*, *Hartia sinensis*, *Eurya loquaiana*, *E. pseudopolyneura*, *Cinnamomum parthenoxylum*, *C. japonicum*, *C. chingii*, and *Phoebe bournei*. In addition, there are some species of Hamamelidaceae and Elaeocarpaceae, which are frequently mixed with species of *Fagus*. In the western subtropical region, the forests consist mainly of *Castanopsis orthacantha*, *C. hystrix*, *Machilus yunnanensis* var. *duclouxii*, *M. kurzii*, *Actinodaphne reticulata*, *Schima wallichii*, *S. argentea*, *Manglietia insignis*, *Magnolia championii*, and *Illicium yunnanense* (Fig. 21).

8. *Broad-leaved evergreen forests of the transitional tropical zone.* References: Chang et al. (1955); Ho and Chen (1963). These transitional forests occur at the boundaries between the subtropical and tropical zones. They are more or less similar in general appearance and structure to those of the tropical rain forests in containing mostly evergreen, broad-leaved trees with plank-buttress roots, stranglers, and cauliflory. However, in so far as dominance of trees is concerned, these forests are similar to the broad-leaved evergreen forests of the subtropics. The dominants are warm-loving trees of the Fagaceae, Lauraceae, Theaceae, Hamamelidaceae, and Elaeocarpaceae, which are mixed with some tropical trees belonging to the Euphorbiaceae, Melastomataceae, Proteaceae, Leguminosae, Moraceae, Myrtaceae, etc.

9. *Broad-leaved evergreen sclerophyllous woodlands or scrubs of the subtropical zone.* References: Editorial Board of Szechuan's Vegetation (1980). The distribution of such evergreen sclerophyllous woodlands is restricted mainly to

the dry, sunny slopes on the mountains of the eastern Chinghai-Tibet Plateau at elevations ranging from 1,000 to 4,200 m. The climate is warm with a distinct dry season, and the annual precipitation is less than 1,000 mm. Under these climatic conditions, the dominant evergreen oaks have small, thickish, leathery, spiny leaves that prevent excessive transpiration. Thus, they form hard-leaved woodlands similar to those around the Mediterranean Sea. The oaks are *Quercus semecarpifolia*, *Q. aquifolioides*, *Q. spinosa*, *Q. longispica*, and *Q. senescens*. They can form forests, woodlands, or scrub in various habitats on the mountains; however, dwarf woodlands are commonly seen (Fig. 22).

10. *Bamboo evergreen forests of subtropical and tropical zones.* Reference: Editorial Board of Szechuan's Vegetation (1980). These bamboo forests are extensively distributed in subtropical and tropical China. There are many species of bamboos. Some bamboo forests are natural, but many are man-made. Different species adapt to different habitats. Species of *Sinarundinaria* are usually found naturally at high elevations in the mountains. Because bamboo stems have many uses, many species are widely cultivated in the subtropics. Among them, *Phyllostachys pubescens*, the young shoots of which are edible, is more commonly planted on acid soils, whereas *Sinocalmus affinis* is grown on calcareous soil. On marshy soils near river banks, *Phyllostachys congesta* is frequently encountered.

11. *Tropical broad-leaved semi-evergreen forests (tropical semi-evergreen seasonal forests).* References: Chang et al. (1955); Hou and Chu (1955); Kwangtung Institute of Botany (1976); Li (1956); Li et al. (1964). These forests are very similar in structure and appearance to tropical rain forests, but as the dry season becomes more distinct they merge into another type. Because the dominant trees are partly evergreen and partly deciduous, these forests are known as "semi-evergreen forests." This type differs from the tropical rain forests in several characteristics. The trees of the upper layer are lower and very few of the larger trees are buttressed. Furthermore, lianas and epiphytes are noticeably scarcer than in the tropical rain forest.

These forests can be classified into two groups. One group growing on limestone soils is widespread throughout southwestern Kwangsi and southern Yunnan provinces. It is composed of calcium-loving trees, such as *Ulmus lanciifolia*, *Gironniera nitida*, *Celtis austro-sinensis* (*Ulm-*



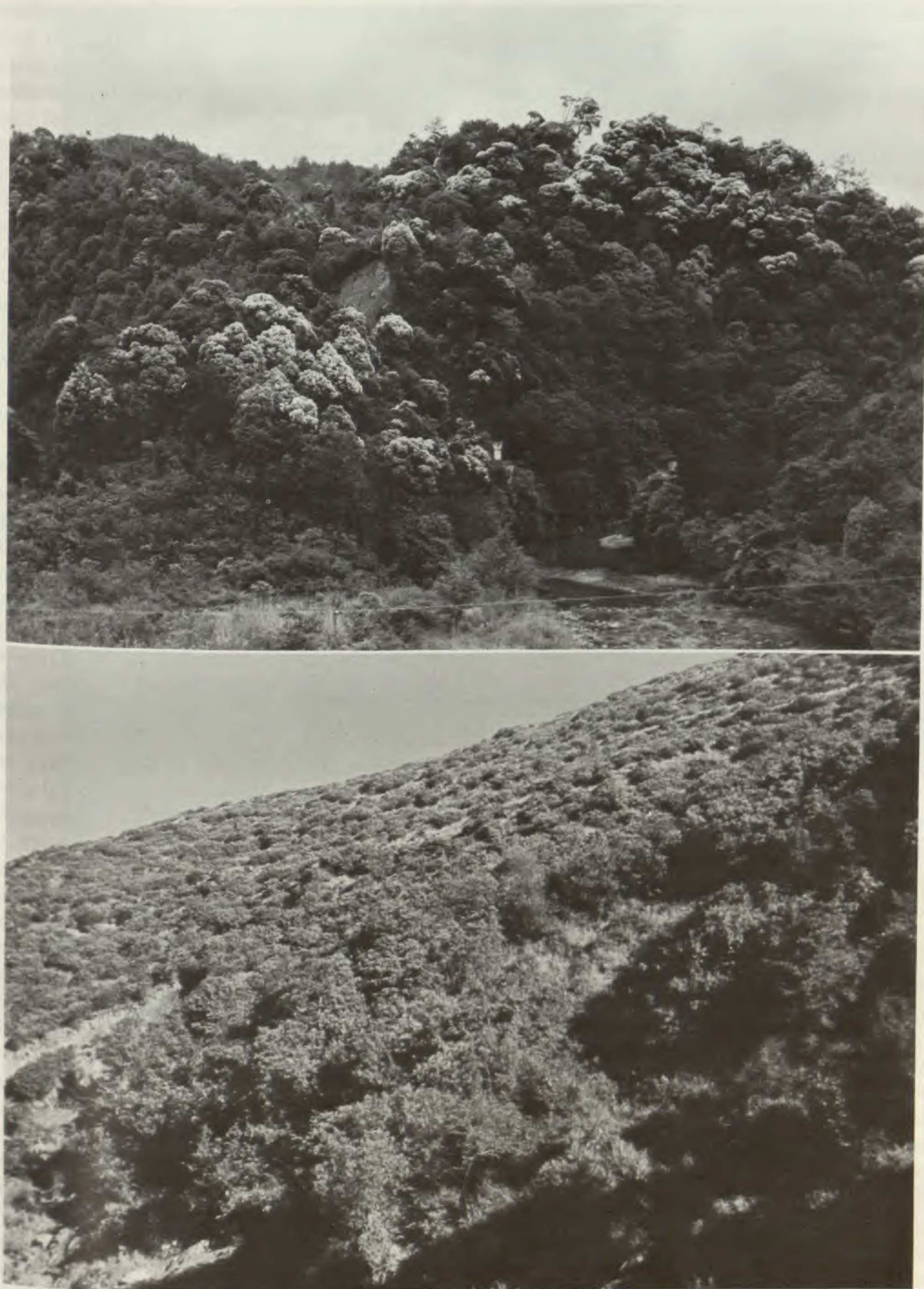


FIGURE 21. (Upper) Broad-leaved evergreen forest found on the acid soil in the subtropical region is dominated by evergreen oaks, consisting of *Castanopsis*, *Lithocarpus*, *Cyclobalanopsis*, and of *Schima superba* (with white-colored flowers).

FIGURE 22. (Lower) On the lee side of wet wind in the mountains of western Szechuan Basin, sclerophyllous woodland dominated by *Quercus aquifolioides* is found.



ceae), *Colona sinica*, *Burretiodendron hsienmu* (Tiliaceae), *Pometia tomentosa*, *Pseudonephelium confine*, *Delavaya yunnanensis* (Sapindaceae), *Muricococcum sinense*, *Drypetes perreticulata*, *D. confertiflorum* (Euphorbiaceae), *Garcinia tinctoria*, *G. paucinervis* (Guttiferae), *Caesalpinia sepiaria* (Leguminosae), etc. The second group is found on acid soils, mainly on western Hainan Island. It consists of trees such as *Kleinhovia hospita*, *Pterospermum heterophyllum*, *Heritiera angustata* (Sterculiaceae), *Chukrasia tabularis*, *Walsura cochinchinensis* (Meliaceae), *Spondia spinnata*, *Lannea grandis* (Anacardiaceae), *Antiaris toxicaria* (Moraceae), *Hainania trechosperma*, and *Microcos paniculata* (Tiliaceae).

12. *Tropical broad-leaved evergreen rain forests.* Reference: Kwangtung Institute of Botany (1976). Tropical rain forests are found locally on the eastern sides of Hainan and Taiwan Islands and in southern Yunnan Province where the local climate is saturated with moisture throughout the year. The forests are characterized by numerous species of evergreen trees. Giant trees, usually clothed with ferns, mosses, and epiphytes belonging to Orchidaceae and Araceae, reach a height of more than 30 m or more and often exhibit plank-buttresses and cauliflory. Stranglers are also characteristic.

These tropical rain forests are remarkable in their floristic richness. There are many trees belonging to the Lauraceae, Euphorbiaceae, Moraceae, Myrtaceae, Annonaceae, Apocynaceae, Sterculiaceae, Sapotaceae, Palmae, Rubiaceae, Myrsinaceae, Leguminosae, Dipterocarpaceae, Meliaceae, Sapindaceae, Aquifoliaceae, Theaceae, Rutaceae, Fagaceae, Proteaceae, and Samyaceae (Flacourtiaceae).

Some representative species found in tropical rain forests in different localities are: *Vatica astrotricha*, *Amesiodendron chinense*, and *Tarrietia parvifolia*, in southern Hainan; *Dipterocarpus yunnanensis*, *Crypteronia paniculata*, *Pometia tomentosa*, *Terminalia myriocarpus*, and *Erythrina lithosperma*, in southern Yunnan; and *Myristica cagayanensis*, *Pterospermum niveum*, *Sideroxylon duclitan*, and *Artocarpus lanceolata*, in southeastern Taiwan (Fig. 23).

#### SCRUB AND COPPICEWOODS

1. *Broad-leaved deciduous scrub of the temperate zone.* Reference: Chen (1958). Leaf-shedding by shrubs of the temperate zone in

northern and northwestern China is an adaptation to a cold season. The broad-leaved deciduous scrub is actually composed of two groups. One consists of primary vegetation that occurs on semi-arid sand dunes, with species of *Cargana*, *Salix*, and *Artemisia*, and on arid saline meadow soil mainly with species of *Tamarix*. The second, consisting of secondary vegetation formed after the felling of temperate forests, includes northern and southern scrubs. The northern temperate shrubs are dominated by *Corylus heterophylla*, *Lespedeza bicolor*, and coppicewood of *Quercus mongolica*, whereas the southern temperate shrubs are dominated by *Vitex negundo*, *Zizyphus jujuba*, *Cotinus coggygria* var. *cinerea*, *Coriaria sinica*, *Dalbergia hupeana*, and *Platycarya strobilacea* (Fig. 24).

2. *Mixed broad-leaved evergreen and deciduous scrub on acid soils of subtropical and tropical zones.* Reference: Hou (1951). Scrub growing on acid soils is all secondary, replacing subtropical and tropical forests after felling or fires, and is characterized by sunny and acid-loving plants. In the subtropical zone, scrub vegetation is dominated by shrubs belonging to the Ericaceae, Theaceae, Hamamelidaceae, and Fagaceae. *Rhododendron simsii*, *R. decorum*, *Vaccinium bracteatum*, *V. fragile*, *Eurya nitida*, *Ternstroemia gymnanthera*, *Loropetalum chinense*, and coppices of *Quercus fabri*, *Q. variabilis*, *Q. acutissima*, and *Castanea sequinii* are representative species. In the tropical zone, shrubs mostly belong to the Myrtaceae, Euphorbiaceae, Hypericaceae, Sterculiaceae, Rubiaceae, Theaceae, Rosaceae, etc. Representative species are *Rhodomyrtus tomentosa*, *Beackea frutescens*, *Melastoma candidum*, *M. normale*, *Aporosa chinensis*, *A. yunnanensis*, *Schima villosa*, *S. wallichii*, *Phyllanthus emblica*, and *Psychotria rubra*.

3. *Mixed broad-leaved evergreen and deciduous thorny scrub on limestone soils of subtropical and tropical zones.* Reference: Hou (1951). This scrub forms successional communities in limestone regions in subtropical and tropical zones. Calcareous limestone soil is excessively drained due to sinkholes, and therefore has low water-holding capacity. The shrubs on these soils exhibit greater defoliation and a marked calcicolous and xerophilous character and are thornier and/or more succulent in response to the dryness and high lime content of the soil.

In the subtropical zone, the plants belong to the Rosaceae, Rutaceae, Caprifoliaceae, Berber-





FIGURE 23. During the dry season in Yunnan Province, because of the presence of clouds that compensate for a shortage of rainfall in the winter, tropical rain forest is found locally in the valley. The tree is *Antiaris toxicaria* (Moraceae).

idaceae, Anacardiaceae, Rhamnaceae, Leguminosae, Euphorbiaceae, Ulmaceae, Meliaceae, Juglandaceae, etc. Typical genera are *Rosa*, *Rubus*, *Zanthoxylum*, *Berberis*, *Rhamnus*, *Viburnum*, and typical species include *Nandina domestica*, *Loropetalum chinense*, *Phyllanthus*

*reticulatus*, *Prinsepia utilis*, and *Platycarya strobilacea*. In addition to the above-mentioned families, shrubs occurring in the tropical zone also consist of plants belonging to the Moraceae, Urticaceae, Sapotaceae, Sterculiaceae, Apocynaceae, Flacourtiaceae, Sapindaceae, etc. The



representative species include coppices of *Ficus* spp., *Alchornea trewioides*, *Boehmeria nivea*, *Clausena excavata*, *Sapium rotundifolium*, *Sterculia lanceolata*, *Desmos cochinchinensis*, *Pleomele nepalensis*, *Pterospermum heterophyllum*, *Terminalia hainanensis*, and *Wrightia hainanensis*.

4. *Broad evergreen sclerophyllous forests or scrub (mangrove) of the littoral subtropical and tropical zones.* Reference: Kwangtung Institute of Botany (1976). Along tropical and subtropical coasts of southern China, mangrove forests or scrub are distributed in muddy tidal marshes of estuaries. The best-developed mangrove forests, which can reach 10 to 15 m and have climbers, are found in the eastern part of Hainan Island at about 19°N. With increasing latitude, the number of species decreases until one species, *Avicennia marina*, remains. It occurs as 1 to 2 m-high shrubs at 27°N in North Fukien Province.

The evergreen leaves of mangroves possess a marked xerophilous structure and succulent character adapted to soil salinity. The chief mangrove genera are *Rhizophora*, *Bruguiera*, and *Ceriops*. They have viviparous seedlings and stilt roots or pneumatophores.

On the northern coast of the transitional tropics occur only five species, namely *Avicennia marina*, *Acanthus ilicifolius*, *Kandelia candel*, *Bruguiera conjugata*, *Aegiceras corniculatum*, which form shrubs less than 3 m tall. On the southern coast of Hainan Island more species of mangrove are present, namely, *Rhizophora apiculata*, *R. mucronata*, *Ceriops tagal*, *Bruguiera sexangula*, *B. cylindrica*, *Myoporum bontiodes*, *Lumnitzera racemosa*, *Excoecaria agallocha*, *Hibiscus tiliaceus*, *Sonneratia caseolaris*, *Xylocarpus granatum*, *Scyphiphora hydrophyllacea*, and *Heritiera littoralis*. These mangrove species can reach 10 to 15 m, but are usually 5 m tall, and can include some climbers, namely *Dischidia chinensis*, *Derris trifoliata*, *Caesalpinia nuga*, and *Stenochlaena ilicifolius* (Fig. 25).

5. *Broad-leaved evergreen succulent scrub on coral islands of the tropical zone.* Reference: Chang (1974). In the South Sea of China are numerous coral islands where evaporation is greater than precipitation because of strong winds throughout the year. Shrubs 2 to 5 m tall growing on coral limestone soil along sandy beaches are evergreen and have succulent leaves and stems or leathery leaves that decrease the rate of transpiration. The vegetation is poor in floristic composition. Plants with thick succulent leaves are

namely *Scaevola frutescens*, *S. hainanensis*, *Messerschmidia argentea*, *Guettarda speciosa*, *Morinda citrifolia*, and *Premna integrifolia*. A 5 to 8 m tall woodland dominated by *Pisonia grandis* is found in the center of the coral islands.

6. *Broad-leaved evergreen semi-sclerophyllous thickets (shrublands) on the mountains of temperate and subtropical zones.* Reference: Zhuo (1975). Areas dominated by semi-sclerophyllous *Rhododendron* species are commonly distributed beyond the limits of arborescent growth in the eastern Chinghai-Tibet plateau in alpine regions from 3,200 to 5,000 m in elevation. Typically, these communities are dense and are composed of dwarf, evergreen shrubs 2 to 15 dm tall. The shrubs are usually creeping, and their leaves are often leathery, thus reducing transpiration. *Rhododendron* species mixed with *Sinarundinaria* are frequently seen in the subalpine belt where they are always secondary after the felling of subalpine conifers. In some places deciduous shrubs, such as species of *Salix*, *Potentilla*, and *Caragana*, are also associated.

7. *Broad-leaved deciduous thickets (alpine shrublands) on the high mountains of temperate and subtropical zones.* Reference: Chang and Wang (1966). Alpine broad-leaved deciduous shrublands are distributed on the mountains of the eastern Chinghai-Tibet Plateau and in the northwestern high mountains. They usually are found on shady slopes in the high mountains beyond the limits of arborescent growth, whereas alpine meadows are seen on sunny slopes at the same elevation. The thickets are mainly composed of *Salix oritrepha*, *S. cupularis*, *Caragana jubata*, and *Potentilla fruticosa*.

8. *Tundras with evergreen dwarf-shrubs and mosses (mountain dwarf-shrub tundra) on high mountains in the temperate zones.* References: Chen et al. (1964); Chow and Li (1964). The mountain dwarf-shrub tundra is poorly developed on the summit of the temperate high mountains of the Changbaishan, Altai, and greater Khingan ranges. The soil is acid, and the climate is characterized by high humidity, strong winds, a short growing season, and local permafrost. The vegetation consists of dense growths of evergreen dwarf shrubs, mainly belonging to the Ericaceae, about 10 to 20 cm high and with small and tough leaves. Representative species are *Vaccinium vitis-idaea*, *Rhododendron aureum*, *R. confertissimum*, *R. redowskianum*, *Phyllodoce caerulea*, *Arctous japonicus*, *Empetrum sibiricum*, and deciduous dwarf shrubs such as





FIGURE 24. (Upper) Broad-leaved deciduous scrub is the secondary growth of the warm-temperate forest. *Cotinus coggygia* var. *cinerea* occurs on the shady slopes, whereas *Zizyphus jujuba* is found on sunny slopes.

FIGURE 25. (Lower) The best-developed mangrove, with 16 or 17 species, is encountered in the eastern part of Hainan Island. The mangrove trees or shrubs have stilt roots.



*Arctous ruber*, *Salix rotundifolia*, *S. polyadenia*, *Betula rotundifolia*, and mosses and lichens (Fig. 26).

9. *Alpine deciduous cushion sub-shrubs mixed with herbs of temperate and subtropical zones*. Reference: Chang and Wang (1966). The cushion sub-shrubs occur principally on the summits of mountains on the northwestern Chinghai-Tibet Plateau from 4,800 to 5,200 m in elevation. The plants assume the form of creeping dwarf sub-shrubs 2 to 5 cm high with richly developed, branched, horizontal axes that spread over the ground. The branches of these cushion plants are so compacted together that they touch each other on all sides. The climatic conditions under which this vegetation type grows resembles those of the mountain dwarf-shrub tundra in coldness and strong wind. However, they differ from those in that the humidity and precipitation are much lower, and the soil is alkaline. Because of this, acid-loving, ericaceous plants are absent, and the floristic composition of this vegetation type is entirely different. The plants belong mostly to the Caryophyllaceae (*Arenaria musiformis*, *A. diapensoides*), Primulaceae (*Androsace tapete*), Leguminosae (*Caragana saja*, *Oxytropis* spp.), Compositae (*Saussurea involucrata*), Rosaceae (*Potentilla* spp.), as well as species of Cyperaceae and Gramineae.

#### DESERTS AND XEROPHYTIC SHRUBS

1. *Temperate deciduous dwarf semi-shrubby deserts*. Reference: Integrated Survey Team of Sinkiang and Institute of Botany, Academia Sinica (1978). These deserts are stony, hilly, or sandy-pebbly with an extremely arid climate, and occur in western China. Only a few low-growing xero-halophytic plants occur infrequently in the cracks of rocks and in erosion gullies. However, a vast area of hills and the gravelly piedmont is devoid of vegetation. The soil contains a certain amount of gypsum. Dominant plants are *Salsola passerina*, *Reaumuria soongarica*, *Sympegma regelii*, *Iljinia regelii*, *Anabasis salsa*, *A. brevifolia*, and *Nanophyton erinaceum*. All these species are xerophytic halophytes, and the first two are gypsum plants that contain 1–4% of sulfur (Fig. 27).

2. *Temperate dwarf hairy sub-shrub deserts with ephemeral forbs*. References: Integrated Survey Team of Sinkiang and Institute of Botany, Academia Sinica (1978); Li (1961). This type of desert is found on loess-like, salt-free

soils. It occurs on the lower slopes of mountains in the Dsungaria Basin where, although the annual precipitation is not more than 200 mm, it is distributed evenly throughout the year. The vegetation is predominantly composed of hairy dwarf-shrubs, namely, *Artemisia kaschgarica*, *A. borotalensis*, and *A. terrae-albae*, as well as some ephemerals that develop in spring, when the soil is moist, but fade quickly with the coming of summer. The perennial ephemerals commonly seen are *Poa bulbosa* var. *vivipara* and *Carex physodes*. Annuals are *Trigonella arcuata*, *Meniocus linifolius*, *Tetracme quadricornis*, and *Lepidium perfoliatum*, as well as *Ferula* spp., which are occasionally encountered.

3. *Temperate succulent halophytic dwarf sub-shrub deserts*. References: Integrated Survey Team of Sinkiang and Institute of Botany, Academia Sinica (1978); Wang (1964). This type of desert is extensively distributed in arid regions on soils with brackish underground water close to the surface, in the lower reaches of rivers, in hollows, or around salt lakes. The soils often have salt crystallizing on the surface with 10 to 30% NaCl or Na<sub>2</sub>SO<sub>4</sub>. Halophytes, such as *Kalidium foliatum*, *K. cuspidatum*, *K. gracile*, *K. caspicum*, *Halostachys belangeriana*, *Halocnemum strobilaceum*, *Suaeda physophora*, *S. microphylla*, *Nitraria sibirica*, and *Lycium ruthenicum* are dominants. Annual succulent hydrohalophytes, namely, *Salicornia europaea* and *Suaeda salsa*, occur on rather moist saline soil.

4. *Temperate shrub and sub-shrub deserts*. References: Hwang et al. (1962); Integrated Survey Team of Sinkiang and Institute of Botany, Academia Sinica (1978). This type of desert is widespread on the sand dunes and piedmont plains in the arid region. In the eastern gravelly Gobi plains with about 200 mm annual precipitation, the predominant shrubs are *Caragana tibetica*, *Tetraena mongolica*, *Potaninia mongolica*, *Ceratoides latens*, and evergreen *Ammodendron mongolicum*. On the sand dunes, which can retain larger amounts of water, *Artemisia sphaerocephala*, *A. ordosica*, *Oxytropis aciphylla*, *Caragana microphylla*, and *C. korshinskii* occur. In the extremely arid area of the western region, *Ephedra przewalskii*, *Zygophyllum xanthozylon*, *Z. kaschgaricum*, *Nitraria sphaerocarpa*, and *Calligonum roborowskii* are scarce on the piedmont plains along the channels of temporary streams that are fed by the sur-





FIGURE 26. (Upper) Mountain dwarf-shrub-tundra, dominated by *Vaccinium vitis-idaea*, *Rhododendron aureum*, and other species of Ericaceae, is seen above 2,000 m on the upper mountains of Changpaishan in northeastern China, above the forests.

FIGURE 27. (Lower) Rocky or hilly desert lacking all vegetation, in the Turfan Basin where annual precipitation usually is less than 20 mm. However, in the oasis, grapes grow very well under irrigation.



rounding snow-covered, high mountains. The sandy Takla-Makan desert is essentially devoid of vegetation, but *Tamarix* spp. are sparsely distributed in the dune valleys (Figs. 28, 29, 30).

5. *Temperate semi-arboreal deserts (Saksaoul communities)*. References: Hu (1963); Integrated Survey Team of Sinkiang and Institute of Botany, Academia Sinica (1978). *Haloxylon ammodendron* and *H. persicum* are characteristic plants growing on the sandy deserts. Originally, *H. ammodendron* was widely distributed in the arid region of China, but it is now scarce in the Darim Basin. This species is a halophyte and is always associated with numerous saline plants. It usually grows on the bottom of sand dunes with moist and slightly saline soil or on salty soil with ground water at a depth of 5 to 8 m, which can be reached by the roots of this plant. This low tree can attain a height of 5 to 7 m and form small woods. *Haloxylon persicum*, a non-saline plant, is confined to the slopes or ridges of stabilized or semi-stabilized sand dunes in the Dsungaria Basin, where annual precipitation is distributed evenly throughout the year. Its growth is dependent upon rainfall, but not ground water. It often grows together with *Calligonum leucocladium*, *Artemisia santolina*, and *A. terrae-albae*, as well as some spring ephemerals (Figs. 31, 32).

6. *Cold high-mountain deserts with creeping or matted dwarf sub-shrubs of the temperate zone (cold high-plateau deserts)*. Reference: Integrated Survey team of Sinkiang and Institute of Botany, Academia Sinica (1978). The cold high-plateau deserts are situated in the northwestern part of the Chinghai-Tibet Plateau, ranging in elevation from 4,600 to 5,500 m. They are characterized by the most extreme type of climate. The annual mean temperature ranges from  $-8^{\circ}$  to  $-10^{\circ}\text{C}$ ; only July has a positive mean ( $10^{\circ}\text{C}$ ). Daily temperature variations of as much as  $60^{\circ}\text{C}$  can occur, but the rainfall seldom exceeds 100 mm. The wind is strong throughout the year. The vegetation is extremely poor in floristic composition, and it is composed of creeping dwarf scrubs. The dominant plant is *Ceratoides compacta* (Chenopodiaceae), associated with *Pegaeophyton scapiflorum*, *Hedinia tibetica*, *Parrya exscapa* (Cruciferae), *Oxytropis poncinsii* (Leguminosae), *Ajania tibetica*, *A. scharnhorstii*, and *Saussuria glandulifera* (Compositae). They are all mostly 4 to 15 cm tall (Fig. 33).

7. *Tropical and subtropical succulent thorny*

*shrubs*. Reference: Editorial Board of Szechuan's Vegetation (1980). This type of vegetation, which always forms a complex with savannas in subtropical and tropical China, is somewhat allied to the southern Asiatic deserts. Because the potential evaporation is much greater than the precipitation in places where this type of vegetation occurs, the vegetation consists of xerophytes and succulents that require a certain minimum amount of water uptake even in periods of drought. Therefore, under warm and dry climatic conditions, plants with succulent stems such as *Opuntia ficus-indica* and *Euphorbia royleana*, and those with succulent leaves such as *Aloe vera* var. *chinensis*, *Kalanchoe pinnata*, etc. predominate. Additional plants are *Zizyphus mauritiana*, *Z. montana*, *Acacia farnesiana*, *Campylotropis yunnanensis*, *C. muehleana*, *Pandus tectorius*, and *Phoenix hanceana*, which are shrubs that have small, hard leaves or are clothed with hairs or spinules that offer some protection from excessive transpiration.

#### STEPPE AND SAVANNAS

1. *Temperate forb-grass steppes (mesoxerophytic steppes or meadow steppes)*. References: Li (1962); Zhu (1958). This type of steppe is found in the temperate zone under a semi-humid climate with an annual precipitation of 350 to 500 mm. It is composed mainly of mesoxerophytic and sod-forming rhizomatous grasses, and subordinate tussock grasses mixed with numerous mesophytic herbs. It also is frequently associated with mesoxerophytic shrubs. Dominants belong mainly to the Gramineae, Compositae, and Leguminosae, as well as the Rosaceae, Ranunculaceae, Liliaceae, Umbelliferae, Scrophulariaceae, Caryophyllaceae, Campanulaceae, etc. Representative dominant species are *Aneurolepidium chinense*, *Stipa baicalensis*, *Filifolium sibiricum*, etc., usually mixed with shrubs including *Prunus sibirica*, *Salix mongolicus*, and *Ulmus pumila* in the north. In the south are *Bothriochloa ischaemum* and *Themeda triandra* var. *japonica*, which are frequently associated with shrubs such as *Zizyphus sativa* var. *spinosus*, *Sophora viciifolia*, *Hippophae rhamnoides*, *Rosa hugonis*, and *Prinsepia uniflora* (Fig. 34).

2. *Temperate needlegrass steppes*. References: Li (1962); Wang (1963). This type of steppe is distributed in the semi-arid region of the Inner Mongolia Plateau and Loess Plateau where the





FIGURE 28. (Upper) *Zygodophyllum*, *Calligonum*, *Nitraria*, are sparsely distributed on the piedmont plains in the channels of temporary runoff in the southern desert region.

FIGURE 29. (Lower) *Ephedra przewalskii* occurs on the piedmont plains in the desert region.





FIGURE 30. (Upper) The wandering sandy desert Takla-Makan is essentially devoid of vegetation, but *Tamarix* spp. can be found very infrequently in the dune hollows. This air photograph was taken at about 1,000 m above the ground.

FIGURE 31. (Lower) In the Soongaria Basin of the desert region, the growth of *Haloxylon persicum* is confined to the slopes or ridges of semi-stabilized or stabilized sand dunes.





FIGURE 32. *Haloxylon ammodendron* was originally widespread in the entire desert region that had a ground water table at a depth of 5 to 8 m, which can be reached by roots of the plant. It usually is found on moist and saline soil.

annual precipitation is 250 to 350 mm. The vegetation is principally composed of xerophytic tussock grasses, such as *Stipa grandis*, *S. krylovii*, *S. breviflora*, and *Cleistogenes squarrosa*, that possess very extensive, finely branched root sys-

tems and narrow leaves that regulate their transpiration by inrolling. On sandy soil, sub-shrubs, including *Artemisia frigida*, *Kochia prostrata*, and *Thymus serpyllum*, and spiny shrubs, consisting of *Caragana microphylla*, *C. stenophylla*, etc.,





FIGURE 33. (Upper) The high-cold desert occurring at 5,000 m elevation in the northwesternmost part of the Chinghai-Tibet Plateau has very few species of plants. The dominant plants are *Ceratoides compacta* and *Ajania tibetica*.

FIGURE 34. (Lower) Mesoxerophytic or meadow steppe is distributed on the North East Plain and the eastern part of the Inner Mongolia Plateau, areas having 350 to 450 mm of rainfall annually. The dominant grass is *Aneurolepidium chinense*, and forbs are numerous.



are frequently found. In mountains of the desert region, steppes dominated by *Stipa capillata*, *S. krylovii*, and *Festuca sulcata*, also occupy a vast area (Fig. 35).

3. *Temperate dwarf-shrub or sub-shrub needlegrass steppes (desert steppes or semi-deserts)*. Reference: Li (1962). This type of steppe is a transitional one between desert and steppe, and occurs in the temperate zone in places where the annual precipitation varies from 150 to 250 mm, and where the winters are dry and cold. The vegetation consists mainly of xerophytic subshrubs and dwarf grasses about 10 to 20 cm high. The extremely xerophytic grasses most frequently encountered are *Stipa gobica*, *S. glareosa*, *S. klemenzi*, *S. breviflora*, and *Cleistogenes mutica*. The dwarf sub-shrubs include *Artemisia frigida*, *A. xerophytica*, *Ajania achilleoides*, *A. tricola*, *A. fruticulosa*, *Ceratoides latens*, *Salsola passerina*, and *Anabasis brevifolia*. The xerophytic dwarf-shrubs are *Caragana stenophylla*, *Prunus mongolica*, *Calligonum mongolicum*, and *Reaumuria soongarica*. In addition, *Allium polyrrhizum* and *A. mongolicum* are characteristic herbs of this type of steppe (Fig. 36). This type of vegetation also is found on mountains of the arid region.

4. *Subtropical and tropical savannas*. References: Editorial Board of Szechuan's Vegetation (1980); Kwangtung Institute of Botany (1976). Savanna-like vegetation in China is confined to a limited part of the subtropics and tropics. Savannas can be defined as homogeneous vegetation, consisting mainly of warm-loving and mesoxerophytic tussock grasses with a more or less even scattering of tall and small, evergreen and deciduous trees and thorny scrubs. The dominant warm-loving grasses are *Heteropogon contortus*, *Cymbopogon distans*, etc. Savannas are locally encountered in two regions of China. One group is found in western Yunnan and western Szechuan in the subtropical zone in deep valleys of the Hungtuan Mountains with locally dry and hot climate. There, the grasses are associated with *Zizyphus mauritiana*, *Acacia farnesiana*, and *Bauhinia racemosa*. Another group is distributed on the sandy, tropical coasts of Hainan and Taiwan islands where the grasses occur mixed with *Flacourtia indica*, *Pandanus tectorius*, *Albizia procera*, and *Phoenix hanceana* (Fig. 37).

5. *High-mountain steppes of temperate and subtropical zones (cold high-mountain steppes)*. References: Chang (1963); Wang and

Li (1981). The major portion of western Chinghai and east central Chang Tang from 4,200 and 5,300 m above sea level in the Chinghai-Tibet Plateau is characterized by a continental type of climate with an annual precipitation of 200 to 300 mm. The annual mean temperature is below 0°C, and the wind is strong throughout the year. Low temperature is overcome during sunny weather by the intense insolation; thus daily temperature fluctuation is great. Under this dry and high-cold climate, the vegetation is composed mainly of cold-xerophytic, dense tussock grasses less than 20 cm tall and dwarf sub-shrubs with small, thick, hairy leaves. The dominants are *Stipa purpurea*, *S. subsessiliflora* var. *basiplumosa*, *Festuca olgae*, *Carex moorcroftii*, and *Artemisia wellbyi*, mixed with alpine elements such as *Kobresia* spp., *Thalictrum alpinum*, *Leontopodium alpinum*, and *Thermopsis alpina* (Fig. 38).

#### MEADOW AND SWAMP VEGETATION

1. *Temperate meadows*. References: Chen et al. (1954); Hou et al. (1953); Hou (1954); Wang and Li (1981). Most temperate meadows are not genuinely virginal, but, except for some saline meadows, are communities established under the disruptive influence of human activity and domestic animals. The plants of this vegetation type are mostly mesophytes, but the floristic composition varies with soils. On neutral or calcareous soils occur *Phragmites australis*, *Calamagrostis epigejos*, *Hemarthria compressa* var. *japonica*, *Deyeuxia langsdorffii*, *D. hirsuta*, and *D. angustifolia*, along with many species of forbs belonging to different families. However, there are numerous species of forbs, such as *Sanguisorba officinalis*, *Artemisia laciniata*, *Vicia* spp., and *Hemerocallis minor* associated locally with *Salix* spp. that grow on acid soils on sunny mountain slopes after the cutting of forests.

The floristic composition of halophytic meadows is entirely different from those mentioned above. This type of meadow is widespread in humid, semi-arid, and arid regions of the temperate zone in tidal estuaries along the coasts and inland salt marshes where many species of halophytic grasses and herbs are the same. They are *Aeluropus littoralis*, *Aneurolpidium dasystachys*, *Puccinellia distans*, *Scorzonera mongolica* var. *putjae*, *Xanthium sibiricum*, *Suaeda salsa*, *S. glauca*, *Atriplex littoralis*, *A. sibirica*, *Salicornia europaea*, *Limonium aureum*, *Polygonum*





FIGURE 35. (Upper) The typical steppe of *Stipa grandis* occurs in Central Inner Mongolia.

FIGURE 36. (Lower) Desert steppe has dwarf grasses about 10 to 20 cm tall, including *Stipa gobica*, *S. glareosa*, etc. The xerophytic dwarf semi-shrubs are *Artemisia frigida*, *Ajanía* spp., *Ceratoides latens*, *Salsola passerina*, etc. *Allium polyrrhizum* is a characteristic herb of this type of steppe. The annual mean rainfall is about 200 mm.





FIGURE 37. (Upper) On the lower slopes on the lee side of the Hengtuan Mountains in western Szechuan and Yunnan provinces, subtropical savannas are found. The dominant grasses are *Heteropogon contortus*, *Cymbopogon distans* mixed with trees such as *Pinus yunnanensis*, *Zizyphus mauritiana* and *Acacia farnesiana*.

FIGURE 38. (Lower) Cold high-mountain steppe, occurring in the central part of the Chinghai-Tibet Plateau, is dominated by *Stipa purpurea* and *S. subsessiliflora* var. *plumosa*.



*sibiricum*, and *Triglochin maritimum*. *Achnantherum splendens*, *Karelinia caspica*, and *Alhagi pseudalhagi* are confined to the arid region. However, the associated halophytic shrubs and sub-shrubs differ in these three regions with varying moisture conditions.

2. *Cold high-mountain meadows of temperate and subtropical zones.* References: Chen (1966); Kiang (1964). These meadows are essentially natural communities. They are distributed extensively in the high mountains of the Chinghai-Tibet Plateau beyond the limit of tree growth at elevations from 4,000 to 5,200 m and with an annual precipitation of 350 to 500 mm. They are mainly composed of numerous species of *Kobresia*, such as *K. pygmaea*, *K. tibetica*, *K. royleana*, and *K. humilis* and many alpine forbs such as *Polygonum viviparum*, *Thalictrum alpinum*, *Pedicularis* spp., and some alpine species of grasses. Successional subalpine meadows rich in forbs and grasses, with a few species of *Kobresia*, follow deforestation of subalpine meadows (Fig. 39).

3. *Subtropical and tropical meadows.* Reference: Kwangtung Institute of Botany (1976). The meadow vegetation or mesophytic grassland of humid subtropical and tropical zones is, in general, not a climatic climax, but rather a seral stage of succession formed after the felling of the forests. However, it can gradually merge into forests with the invasion of arborescent forms. The grassy or herbaceous taxa are sensitive to the combined influence of soil acidity and air temperature. The taxa of meadows found on subtropical acid soils are typified by numerous graminoids, such as *Eulalia speciosa*, *E. pallens*, *Miscanthus floridulus*, *Capillipedium parviflorum*, *Rhynchospora rubra*, *Fimbristylis* spp., and are frequently mixed with or dominated by pure stands of evergreen *Dicranopteris dichotoma* mixed with *Lycopodium cernuum* and *L. clavatum*. The meadows also are frequently associated with shrubs belonging to the Theaceae, Ericaceae, etc. However, on tropical, deep, moist, acid soils occur *Apluda mutica*, *Eremochloa ciliaris*, *Ischaenum aristatum*, and *Perotis indica*, as well as *Themeda gigantea*, and *Saccharum arundinaceum*. Evergreen *Blechnum orientale* is frequently seen on open roadsides. The tropical acid meadows are usually composed of shrubs belonging to the Euphorbiaceae, Melastomataceae, etc.

On the calcium or limestone soils the graminoids are represented by *Sporobolus elongatus*, *Bothriochloa intermedia*, *Neyraudia reynandi-*

*ana*, *Heteropogon contortus*, *Pogonatherum crinitum*, *Capillipedium parviflorum*, and *Arthraxon hispidus*. Sometimes they are dominated by pure stands of *Cyclosorus acuminatus*, with *Pteris vittata* in the cracks of limestone rocks. Nevertheless, *Chrysopogon aciculatus*, *Heteropogon contortus*, *Apluda mutica*, *Kyllinga brevifolia*, and *Scleria levis* can be considered representative species on tropical limestone soils.

On tropical, coastal, sandy saline soils, often affected by sea spray, the meadow vegetation consists of graminoids, including *Spinifex littoreus*, *Sporobolus virginicus*, *Perotis indica*, *Cyperus malaccensis* var. *brevifolius*, together with forbs such as *Ipomaea pes-caprae*, *Wedelia prostrata*, *Limonium sinense*, *Suaeda australis*, and shrubby *Vitex trifolia* var. *unifoliata* (Fig. 40).

4. *Swamp vegetation.* The term "swamp vegetation" is applied to a type developing on water-logged soil where the summer water level is close to the ground surface (Meadow of U.S. terminology). In China the floristic composition of swamp vegetation varies with climate and soils. Swamps can also be classified according to their occurrence in temperate, subtropical, tropical, and cold, high mountainous areas (Fig. 41). Under similar climatic conditions, they are differentiated by edaphic factors.

#### VEGETATIONAL REGIONS OF CHINA

The longitudinal zonation of vegetation in the temperate zone, which is closely related to the east-to-west variation in annual precipitation, is shown in Figure 42. In eastern and southeastern China, the different forest regions correspond to the latitudinal zonation from north to south (Fig. 43). In the mountainous areas of the country the zonation of the vegetation is vertical.

Based on the principles of vegetational zonation, the country can be divided into eight vegetational regions (Fig. 44). References: Hou (1960, 1961, 1964, 1981a, 1981b, 1982).

1. *Cold-temperate deciduous needle-leaved forest region.* This region occupies the extreme north of China, embracing a very small area of the northern Greater Kingan Mountains with an annual precipitation of 500 mm. The mean annual temperature is below 0°C, and the extreme minimum is -50°C. The forest consists predominantly of *Larix gmelini* on acid podzolic soils. Many cultivated crops and fruit trees do not ripen in this region; however, potatoes, spring barley, and cabbage grow well.

2. *Temperate deciduous broad-leaved forest*



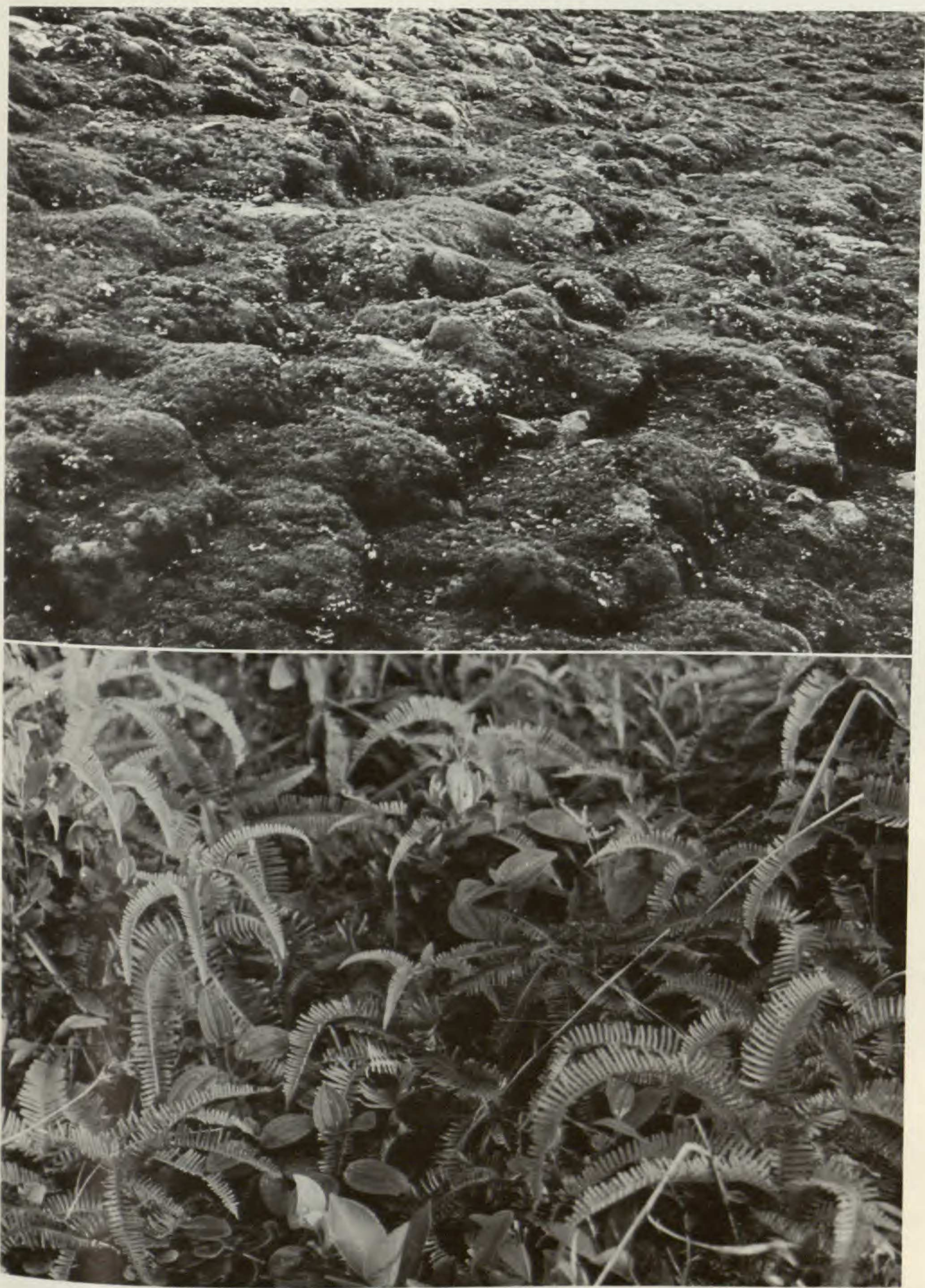


FIGURE 39. (Upper) Cold high-mountain steppe meadow is found at about 5,000 m elevation in the eastern Chinghai-Tibet Plateau. This type of vegetation consists of numerous species of *Kobresia* such as *K. pygmaea* and *K. tibetica*.

FIGURE 40. (Lower) *Dicranopteris dichotoma* is frequently encountered in the ground layer of *Pinus massoniana* woodland. In places, the fern forms pure stands. It, along with various associated plants, indicates strongly acid soil in the humid subtropics and tropics.





FIGURE 41. Swampy meadow of cold high-mountain at about 4,000 m elevation is frequently seen on the eastern Plateau.



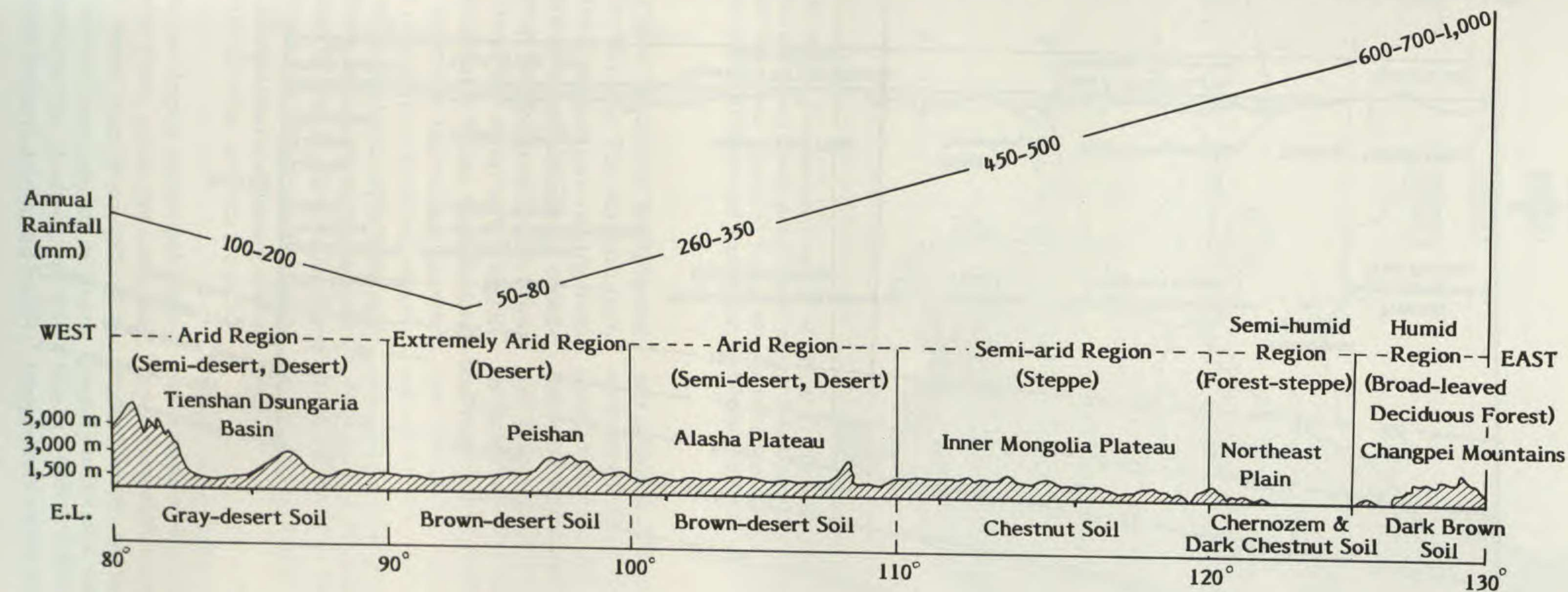


FIGURE 42. Schematic rainfall and soils in relation to vegetational regions varying from west to east in the temperate zone of China (about 42°N).



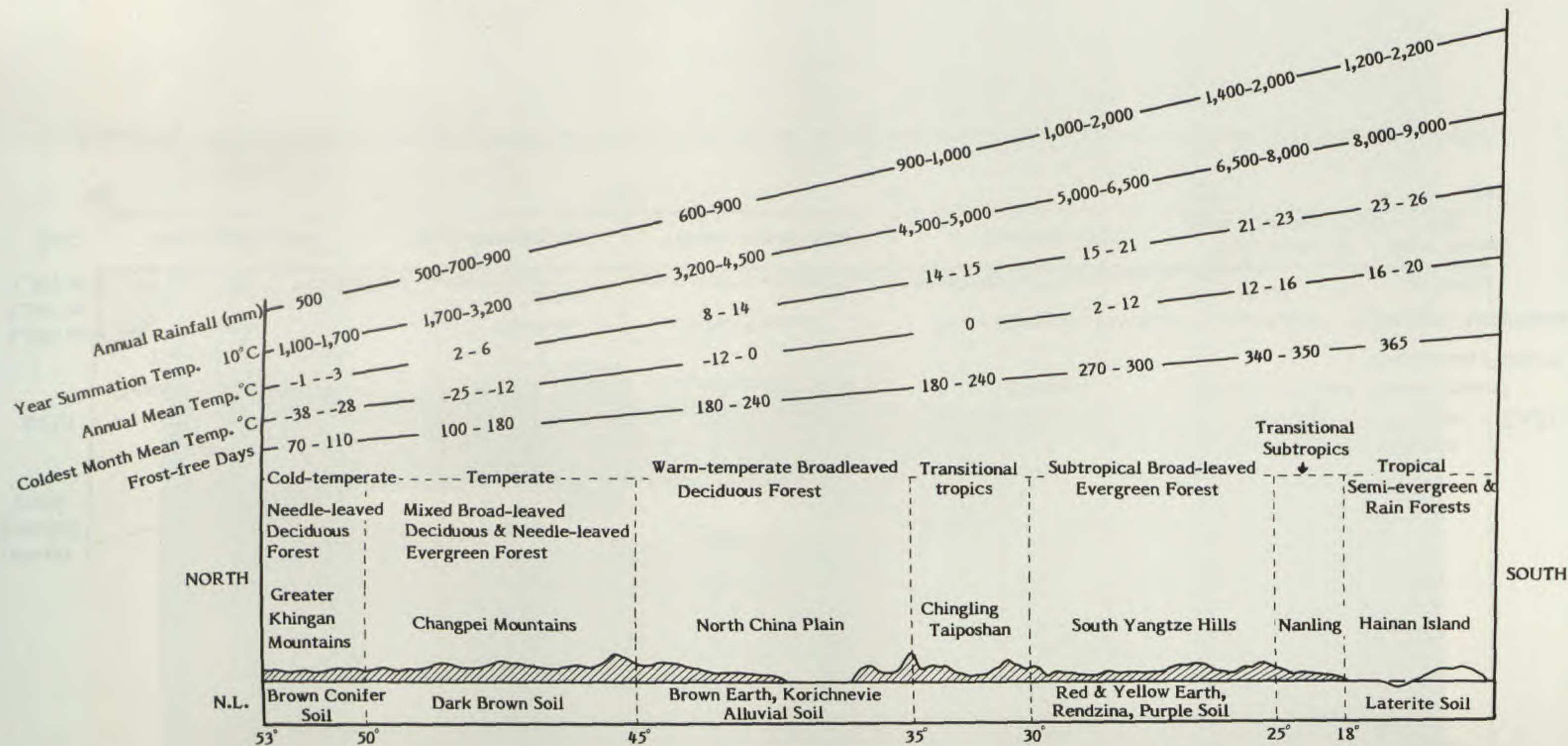


FIGURE 43. Schematic climate and soils in relation to vegetational regions varying from north to south in the eastern section of China (about 120° to 110°E).



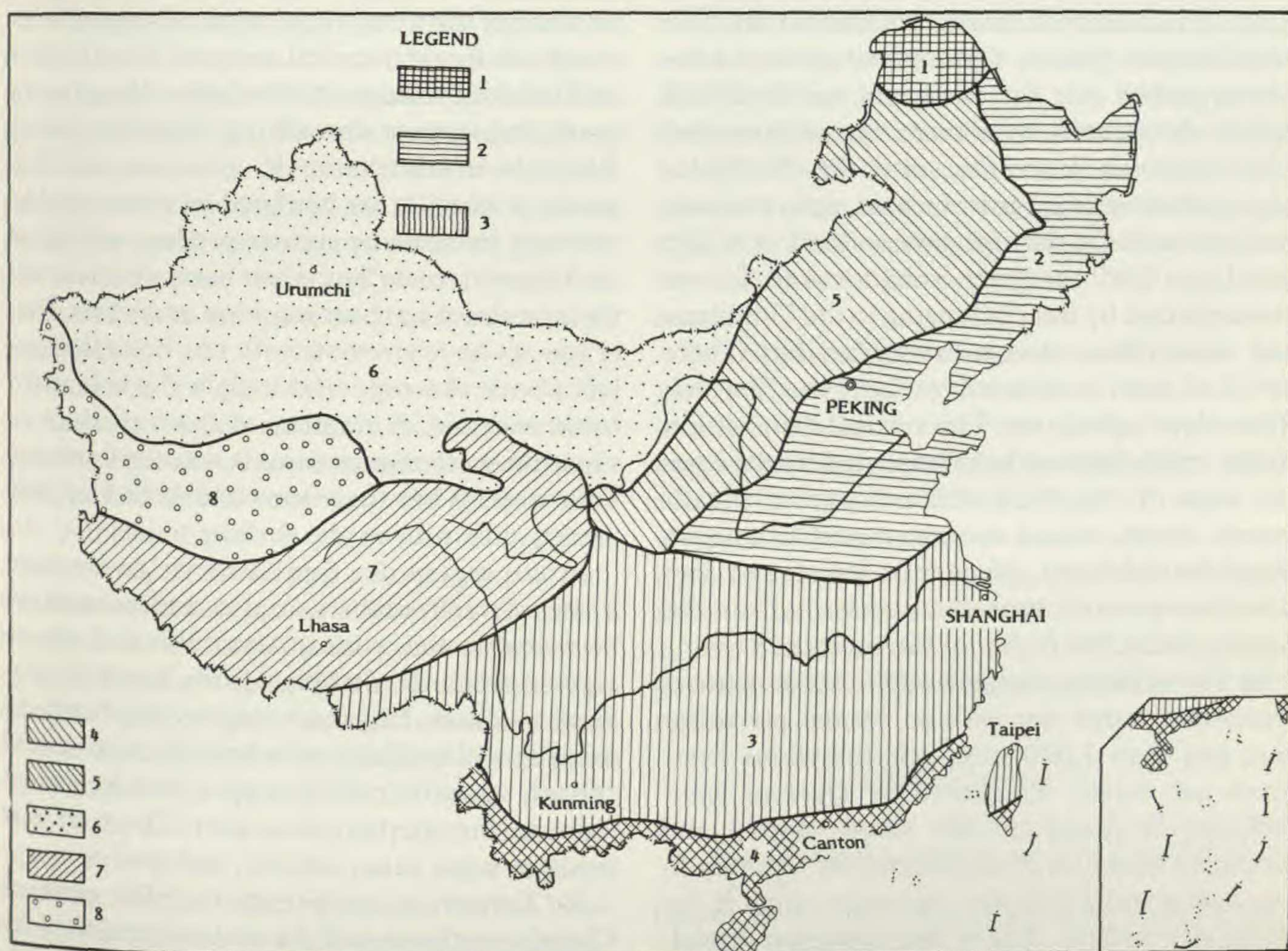


FIGURE 44. Map showing vegetational regions of China: 1) Cold-temperate deciduous needle-leaved forest region; 2) Temperate deciduous broad-leaved forest region; 3) Subtropical evergreen broad-leaved forest region; 4) Tropical seasonal rain forest region; 5) Temperate steppe region; 6) Temperate desert region; 7) High-cold meadow and steppe region; 8) High-cold semi-desert and desert region.

region. In this region the annual precipitation ranges from 600 to 900 mm. The northern part, with the mean annual temperature varying from  $1^{\circ}$  to  $8^{\circ}\text{C}$ , supports a mixed deciduous broad-leaved and evergreen needle-leaved forest. From the lowlands at about 300 m up to the highest peak of Changpaishan at 2,700 m, the following vegetation types appear in succession: *Quercus mongolica* forest; mixed *Pinus koraiensis*-deciduous broad-leaved forest; *Abies nephrolepis* and *Picea jezoensis* forest associated with a secondary forest dominated by *Betula platyphylla*; *Betula ermanii* forest; and the dwarf-shrub tundra. In the valleys and alluvial plains, soybeans, spring wheat, maize, kaoliang, millet, and rice are planted once a year.

The southern part of Region 2 principally covers the North China Plain, where the mean annual temperature varies from  $8^{\circ}$  to  $14^{\circ}\text{C}$ . The deciduous broad-leaved forest consists of *Quercus dentata*, *Q. liaotungensis*, *Q. aliena*, etc. Evergreen needle-leaved forest is dominated by *Pinus tabulaeformis* or *P. densiflora* and grows on acid, brown forest soil. Mixed deciduous broad-leaved forest and the *Platycladus orientalis* forest thrive on the neutral or calcareous Korichnevie soil. Saline meadows are widely distributed along the sea coast. The land is almost entirely under cultivation and usually is planted three times in two years with winter wheat, cotton, peanuts, sweet potatoes, maize, kaoliang, and millet. Rice is locally planted once a year.

Region 2 is the main production area in China of deciduous fruits, namely, apples, pears, grapes, persimmons, chestnuts, walnuts, and Chinese dates.

3. Subtropical evergreen broad-leaved forest region. Occupying a vast area of the southwestern and southeastern part of the country, this region is characterized by different types of subtropical forests. In the eastern subregion, the climate is moist and warm. The annual precipitation is 1,000 to 2,000 mm and the mean annual temperature varies from  $16^{\circ}$  to  $20^{\circ}\text{C}$ . The ever-

green needle-leaved forest is dominated by *Pinus tabulaeformis* or *P. densiflora* and grows on acid, brown forest soil. Mixed deciduous broad-leaved forest and the *Platycladus orientalis* forest thrive on the neutral or calcareous Korichnevie soil. Saline meadows are widely distributed along the sea coast. The land is almost entirely under cultivation and usually is planted three times in two years with winter wheat, cotton, peanuts, sweet potatoes, maize, kaoliang, and millet. Rice is locally planted once a year.



green broad-leaved forest, dominated by *Cyclobalanopsis glauca*, *Castanopsis eyrei*, *Lithocarpus glaber*, etc., the evergreen needle-leaved forest, dominated by *Pinus massoniana* and *Cunninghamia lanceolata*, and the *Phyllostachys pubescens* forest grow on acid, yellow or red, podzolic soils. On the limestone soils occur mixed deciduous and evergreen broad-leaved forests characterized by trees belonging to the Ulmaceae and some other calcium-loving families. There are also forests dominated by *Cupressus funebris*, *Sinocalmus affinis*, etc. The vertical distribution of the vegetation can be represented by the eastern slope of Erlanshan where evergreen broad-leaved forest, mixed evergreen and deciduous broad-leaved forest, *Abies fabri* forest, and *Sin-arundinaria* scrub appear successively from the base to the 3,300 m top of the mountain.

In the western subregion where the climate is warm and rather dry with an annual precipitation less than 1,000 mm, sclerophyllous evergreen oak forest, dominated by *Quercus aquifolioides*, is found on the sunny slopes, and succulent thorn scrub dominated by *Opuntia ficus-indica* and *Euphorbia royleana* occurs in the deep, dry valleys. There the evergreen broad-leaved forest consists of *Cyclobalanopsis glaucoides*, *Castanopsis delavayi*, and *Lithocarpus dealbatus*. *Pinus yunnanensis*, *P. armandii*, and *Cupressus duclouxiana* are the dominant trees of the evergreen needle-leaved forest.

In the eastern subregion two crops consisting of summer rice and winter wheat or rapeseed are usually planted each year. Double-cropping of rice, followed by a planting of a cool-loving crop, also can occur. Cotton, ramie, peanuts, sweet potatoes, maize, and sugar cane are the common crops. Subtropical fruits such as *Citrus* spp., *Myrica rubra*, and other cultivated trees such as tea, tea oil, loquat, tung oil, and mulberry are widely grown. In the western subregion, however, summer rice or maize and winter wheat or rapeseed are planted annually, whereas the fruit trees are mainly deciduous.

4. *Tropical seasonal rain forest region.* This region lies in southernmost China where the annual mean temperature ranges from 21° to 26°C, and the precipitation is 1,200 to 2,200 mm annually. In well-sheltered valleys one can find thick, broad-leaved evergreen rain forest with a wide variety of trees of different heights, some up to 40 m. The massive trunks are supported by buttresses taller than a man and entwined with thick vines. Lovely ferns and brilliant orchids flourish

on some of the trees. Tropical broad-leaved semi-evergreen forest (tropical seasonal forest) occurs on limestone hills or on drier sites. Along the sea coast, mangroves containing *Kandelia candel*, *Rhizophora mucronata*, *R. apiculata*, and *Bru-guiera sexangula* are confined to saline, muddy, swampy soils. Some species produce a tangle of arching prop roots from their base, which enables them to stand up to strong wind and waves. Other species have air-roots with tiny holes that project above the mud and supply the submerged roots with air. A number of them produce viviparous seeds that germinate while still attached to the tree. When these sprouted seeds drop, they readily take root in the shifting mud.

In this region rice frequently yields two crops a year. Sweet potatoes, maize, and peanuts can be raised in the winter. Also cultivated are evergreen orchards of tropical fruits, bananas, pine-apples, lichees, longans, mangoes, and betelnuts, as well as plantations of industrial crops such as rubber, coconut, coffee, pepper, vanilla, and oil palm in the southernmost part. There are also fields of sugar cane, manioc, and sisal hemp.

5. *Temperate steppe region.* The plain of China's northeast and the eastern portion of the Inner Mongolia Plateau is a vast grassland with a semi-arid climate. The eastern part is covered with a mesoxerophytic steppe and meadows dominated by *Aneurolepidium chinense* and *Filifolium sibiricum* that grow on loamy chernozem or dark chestnut soils. Sparse mesoxerophytic woodland dominated by *Pinus sylvestris* var. *mongolica* or *Ulmus pumila* is found on sandy soils. Typical steppe occurs in the western parts of the Inner Mongolian and Loess plateaus, where the xerophytic perennial grasses, *Stipa grandis*, *S. krylovii*, *S. bungeana*, *S. brevifolia*, *S. gobica*, *S. glareosa*, and *Cleistogenes squarrosa* are dominant. The deciduous scrub, including *Salix* spp., *Caragana* spp., and *Artemisia* spp., grows on the sandy soil or sand dunes of this region. Saline meadows and the annual succulent halophytic vegetation frequently occur on soils with high ground-water tables. Grasses and leguminous forage plants in this area are highly nutritional, making the region China's main livestock-raising area. The main domestic animals here are sheep, cattle, and horses.

A number of places in the eastern part of this region have been turned into agricultural areas with state farms raising crops and breeding stock. Their main crops are soy beans, sorghum, and sugar beets.



6. *Temperate desert region.* This region includes the western parts of Inner Mongolia, Kansu, the Tsaidam Basin in Chinghai Province, and the whole of Sinkiang. The characteristic feature of the climate is its dryness; the annual mean precipitation is less than 50 to 150 mm in most places. The sandy deserts and areas of gravelly gobi contain a poor variety of plants. Growth is sparse, and there are stretches that are devoid of vegetation.

Among the few plants that grow in the sandy deserts of this region are *Haloxylon ammodendron*, *H. persicum*, *Artemisia sphaerocephala*, *A. ordosica*, and *Calligonum* spp. On the gravelly gobi patches, *Ephedra przewalskii*, *Nitraria sphaerocarpa*, *Anabasis* spp., *Salsola passerina*, and *Reaumuria soongarica* occur. The succulent halophytic dwarf semi-shrubby desert dominated with *Kalidium* spp., *Nitraria sibirica*, *Halostachys belangeriana*, and *Halocnemum strobilaceum* is confined to solonchak soil. *Sympegma regelii* grows very sparsely in the rocky desert. Most of the above-mentioned plants make excellent camel fodder. The leaves of some of these plants are vestigial, their function having been taken over by green branches to reduce transpiration.

In the temperate desert region *Populus euphratica* woodland, sometimes with *Elaeagnus angustifolia*, is found on river banks. The leaves of *Populus* make an excellent fodder for camels and goats. This tree is the main source of timber in the desert. *Tamarix* scrub occurs on saline meadow soils with a high water table.

The vast grasslands on the slopes of the high mountains in the Chien, Tianshan, Kunlung, and Altai ranges are good grazing grounds. There are timber forests consisting mostly of *Picea* spp. on the upper slopes. The melting of the perpetual ice and snow on the peaks irrigates the oases in the deserts below. The low-elevation basins in this region are centers for growing fruit, such as grapes, watermelons, and Hami melons. Because the strong sunlight and the great fluctuation of temperatures between day and night are favorable for concentrating sugar, the fruits are extraordinarily sweet. In addition, China's best long-staple cotton is grown in the Turfan Basin.

7. *High-cold meadow and steppe region.* The eastcentral and southern portions of the Chinghai-Tibet Plateau are 4,000 m above sea level and have no summer. The melting glaciers produce many marshes, lakes, and meadows with *Kobresia pygmaea*, *K. tibetica*, etc. The high-

mountain alpine steppe occurs in the central part and is dominated by *Stipa purpurea* and *S. subsessiliflora* var. *basiplumosa*. Yaks, Tibetan goats, and sheep are the main domestic animals there. In the valleys of the plateau grow such cold-resistant crops as rapeseed, spring barley, turnips, etc. They are locally seen at elevations below 3,200 m in the north and 4,200 m in the south.

8. *High-cold semi-desert and desert region.* The northwestern corner of Tibet, at 5,000 m above sea level, has even sparser vegetation and fewer varieties of plants. Only short, small sub-shrubs are found here. Some of these are creepers, whereas others are cushion plants, forms that are adapted to resisting wind and cold and preserving moisture. *Ceratoides compacta* and *Ajania tibetica* are frequently found on the sandy gravelly desert. There is no agriculture in this region.

#### LITERATURE CITED

- BRAUN-BLANQUET, J. 1932. Plant Sociology: The Study of Plant Communities. McGraw-Hill Book Co. Inc.
- CHANG, H. T. 1974. Vegetation of the Sisha Islands. Acta Botanica Sinica 16(3). Science Press. (In Chinese.)
- et al. 1955. The plant communities of Tinghushan, Kaouai county, Kwangtung Province. Chungshan Univ. Bull. No. 3. (In Chinese.)
- CHANG, K. W. 1963. The principal characteristics of steppes and their zonal significance in Changtan Plateau. Acta Phytocologica et Geobotanica Sinica 1(1-2). Science Press. (In Chinese.)
- & C. T. WANG. 1966. Vegetation of the Central Tibet. Science Press. (In Chinese.)
- CHANG, Y. L. 1955. The plant communities of the Greater Khingan Mountains. Contribution to Plant Ecology and Geobotany, No. 1. Science Press. (In Chinese.)
- CHEN, C. C. 1955. Observation on ecologically morphological characteristics of certain alpine plants in the eastern Chienlin Mountains, Kansu Province. Acta Phytocologica et Geobotanica Sinica 4(1). Science Press. (In Chinese.)
- & K. Y. Chow. 1957. Vegetation of the Sulian River valley, Kansu Province. Contribution to Plant Ecology and Geobotany, No. 15. Science Press. (In Chinese.)
- CHEN, C. T. 1958. Vegetation of Tsiwuling forest area, Kansu Province in relation to soil and water conservation. Contribution to Plant Ecology and Geobotany, No. 2. Science Press. (In Chinese.)
- , C. T. WANG & H. M. TUNG. 1954. The plant communities of hills and seashores in Lienyunkan, Kiangsu Province. Acta Geographica Sinica 20: 285-311. Science Press. (In Chinese.)
- CHEN, L. C. et al. 1964. The main plant communities and their structural character of the vertical belts on the northern slope of the Changpai Mountains,



- Kirin Province. *Acta Phytoecologica et Geobotanica Sinica* 2(2). Science Press. (In Chinese.)
- et al. 1965. The fundamental characteristics of the mountain vegetation in relation to development of forestry and side-lines in Huairou County, Peking. *Acta Phytoecologica et Geobotanica Sinica* 3(1). Science Press. (In Chinese.)
- CHIANG, Y. S. 1963. On problems of phytocoenosis-characteristics and classification of the sub-alpine dark conifers in the western Szechuan Plateau. *Acta Phytoecologica et Geobotanica Sinica* 1(1-2). Science Press. (In Chinese.)
- CHIEN, S. S., C. Y. WU & C. T. CHEN. 1956. The vegetation types of China. *Acta Geographica Sinica* 22(37-92). Science Press. (In Chinese.)
- CHING, R. C. 1959. On the problem of woodlands dominated by *Populus euphratica* and *P. pruinosa*. Contribution to the physical conditions of Sinkiang Region. Science Press. (In Chinese.)
- CHOW, J. L. 1957. Comments on the mountain vegetation types of west Lake, Chekiang Province. *Futang Univ. Bull. (Natural Science)*, No. 2. (In Chinese.)
- CHOW, K. Y. 1963. Vegetation classification and regionalization of Shantung Province. *Shantung Univ. Bull. (Natural Science)*, No. 2. (In Chinese.)
- CHOW, Y. L. & C. W. LI. 1964. Principal vegetation types and their characteristics of the northeastern mountains of China. *Acta Phytoecologica et Geobotanica Sinica* 2(2). Science Press. (In Chinese.)
- CHU, C. H. & C. W. WEN. 1953. An ecological observation on Nanyashan forests, Chuo County, Anhwei Province. *Acta Botanica Sinica* 2: 349-370. Science Press. (In Chinese.)
- EDITORIAL BOARD OF CHINA'S VEGETATION. 1980. *China's Vegetation*. Science Press. (In Chinese.)
- EDITORIAL BOARD OF SZECHUAN'S VEGETATION. 1980. *Szechuan Province's Vegetation*. People's Press of Szechuan Province. (In Chinese.)
- HO, S. Y. & S. P. CHEN. 1963. Vegetational regionalization of Kwangtung Province. *Acta Phytoecologica et Geobotanica Sinica* 1(1-2). Science Press. (In Chinese.)
- HOU, H. Y. (HOU XUE-YU). 1951. The plant communities of southern Kweichow Province. *Acta Botanica Sinica* 1: 65-116. Science Press. (In Chinese with English summary.)
- . 1954. *The Indicator Plants of Acid, Calcareous, and Saline Soils in China*. Science Press. (In Chinese.)
- . 1956. The vegetation of China with special reference to the main soil types. Report for the 6th International Congress of Soil Science (in Paris).
- . 1960. *Vegetation of China*. Education Press. (In Chinese.)
- . 1961. On the concept and fundamental principles of vegetational regionalization. *Acta Botanica Sinica* 9: 3-4. Science Press. (In Chinese with English summary.)
- . 1964. On the principles, criteria, and units classifying of Chinese vegetational regionalization. *Acta Phytoecologica et Geobotanica Sinica* 2: 2. Science Press. (In Chinese.)
- (Editor- and Author-in-Chief). 1979. *Vegetation Map of China* (1: 4 000 000). Cartographic Publishing House, Peking. (In Chinese with English legend.)
- . 1981a. A further discussion on the principle and scheme of vegetational regionalization of China. *Acta Phytoecologica et Geobotanica Sinica* 5: 290-300. Science Press. (In Chinese with English summary.)
- . 1981b. The geographical distribution of vegetation of China related to the horizontal and vertical zonation. *Act Bot. Bor.-Occ. Sinica* 1(1-2). (In Chinese with English summary.)
- . 1982. *The Vegetation Geography of China with Reference to the Chemical Composition of Dominant Plants*. Science Press. (In Chinese.)
- et al. 1953. A preliminary study on plant associations of Peitaiho, Hopei Province. *Acta Botanica Sinica* 2: 431-465. Science Press. (In Chinese with English summary.)
- HOU, K. C. & C. H. CHU. 1955. The vegetation of Hainan Island and Kwangtung Province. Contribution to Plant Ecology and Geobotany, No. 4. Science Press. (In Chinese.)
- HU, S. T. 1963. Saksaul deserts of the northwestern China. *Acta Phytoecologica et Geobotanica Sinica* 1(1-2). Science Press. (In Chinese.)
- HWANG, Y. S. et al. 1962. Sandy desert vegetation of the eastern Alasha region. *Desert Amelioration Bull.* No. 4. Science Press. (In Chinese.)
- INTEGRATED SURVEY TEAM OF SINKIANG & INSTITUTE OF BOTANY, ACADEMIA SINICA. 1978. *Vegetation of Sinkiang and its Utilization*. Science Press.
- JIAN, Z. P. et al. 1975. Beech forests of Fanginshan, Kweichow Province and their significance in geographical distribution. *Acta Phytotaxonomica Sinica* 13(1). Science Press. (In Chinese.)
- KIANG, S. 1958. Report on the vegetation of Wukanshan, Kiangsi Province. Contribution to Plant Ecology and Geobotany, No. 2. Science Press. (In Chinese.)
- . 1964. The fundamental characteristics and main types of alpine meadows in the western Szechuan Plateau. *Acta Phytoecologica et Geobotanica Sinica* 2(1). Science Press. (In Chinese.)
- KÜCHLER, A. W. 1964. Potential natural vegetation of the conterminous United States. *Amer. Geog. Soc. Special Publ.*, No. 36.
- KWANGTUNG INSTITUTE OF BOTANY. 1976. *Kwangtung Province's vegetation*. Science Press. (In Chinese.)
- LI, C. C. et al. 1964. Discussion on the criteria and characteristics for regionalizing tropics and subtropics from phytoecological viewpoint. *Acta Phytoecologica et Geobotanica Sinica* 2: 253-255. Science Press. (In Chinese.)
- LI, P. 1962. Main types of zonal vegetation in Inner Mongolia with their ecological distribution law. *Inner Mongolia Univ. Bull.* No. 2 (In Chinese.)
- LI, S. Y. 1956. The plant communities of the southern part of Lungchow county, Kwangsi region. Contribution to Plant Ecology and Geobotany, No. 8. Science Press.
- . 1961. The fundamental character of deserts in the northern Sinkiang region. *Acta Botanica Sinica* 1: 1-11. Science Press. (In Chinese with English summary.)



- Sinica 9(3-4). Science Press. (In Chinese with English summary.)
- LIN, Y. et al. 1965. Main vegetation types of Chiangsi. Univ. Bull. No. 3.
- LIU, F. S. 1964. Discussion on the characteristics of three vegetational zones. *Acta Phytocologica et Geobotanica Sinica* 2: 256-261. Science Press. (In Chinese.)
- LIU, T. N. 1939. Phytogeography of southern and southwestern China. *Chinese Journal of Biology* 1: 21-27. (In Chinese.)
- . 1955. *Icones of the Woody Plants of Northeastern China*. Science Press.
- NUMATA, M. 1974. *The Flora and Vegetation of Japan*. Kodansha Ltd., Tokyo.
- SHAN, J. H. & F. S. LIU. 1963. The main vegetation type of Chekiang Province. *Acta Phytocologica et Geobotanica Sinica* 1(1-2). Science Press. (In Chinese.)
- TANSLEY, A. G. 1955. *The British Isles and their Vegetation*. Cambridge Univ. Press, Cambridge.
- TENG, S. C. 1947. The forest regions of Kansu and their ecological aspects. *Bot. Bull. Acad. Sin.* 1: 187-200.
- . 1948. Forest geography of the East-Tibet Plateau. *Bot. Bull. Acad. Sin.* 2: 62-67.
- UNESCO. 1973. *International Classification and mapping of vegetation*. Unesco, Paris.
- WALTER, H. 1973. *Vegetation of the earth in relation to climate and the eco-physiological conditions*. Springer-Verlag, New York.
- WANG, C. T. & B. S. LI. 1981. The main types and characteristics of high cold-steppes in the Changtang Plateau of Sizing. *Acta Phytocologica et Geobotanica Sinica* 5: 1-13. Science Press. (In Chinese.)
- WANG, H. S. 1964. The distribution of halophytic plant communities of Sinkiang Region in relation to soils and groundwater. *Acta Phytocologica et Geobotanica Sinica*. Science Press. (In Chinese.)
- WANG, S. P. 1956. The plant communities in the vicinity of Yenshan, Linkwei county, Kwangsi Region. *Contribution to Plant Ecology and Geobotany*, No. 7. Science Press. (In Chinese.)
- . 1964. A preliminary investigation on the phytocoenosis-characteristics of mixed Cathaya forests in Kwangsi. *Acta Phytocologica et Geobotanica Sinica* 2: 103-110. Science Press. (In Chinese.)
- WANG, Y. F. 1963. The fundamental characteristics of steppes in the Tianshan Mountains. *Acta Phytocologica et Geobotanica Sinica* 1(1-2). Science Press. (In Chinese.)
- WARMING, F. 1909. *Oecology of Plants*. Oxford Univ. Press, Oxford.
- WEAVER, J. E. & F. E. CLEMENTS. 1938. *Plant Ecology*. McGraw-Hill Co., Inc., New York.
- WHITAKER, R. H. 1962. Classification of natural communities. *Bot. Rev. (Lancaster)* 28(1).
- WU, C. L. 1955. Preliminary investigation on the distribution of *Cunninghamia lanceolata*. *Acta Geographica Sinica* 21(3). Science Press. (In Chinese.)
- ZHAO, S. L. 1958. Preliminary report of *Pinus sylvestris* var. *mongolica* woodland growing on semi-arid sandy soil in Inner Mongolia. *Contribution to Plant Ecology and Geobotany*, No. 2. Science Press. (In Chinese.)
- ZHU, T. C. 1958. General comments on the steppes in the northeastern China. *Northeast Teacher Univ. Bull.* No. 1. (In Chinese.)
- ZHUO, Z. D. 1975. The fundamental characteristics and uses of alpine evergreen shrubs of Kansu Province. *Langchow Univ. Bull. (Natural Science)* No. 2. (In Chinese.)